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Kosaki, Takashi

STUDIES ON THE METHOD OF EFFICIENT UTILIZATION OF SOIL SURVEY DATA

TAKASHI KOSAKI

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STUDIES ON THE METHOD OF EFFICIENT UTILIZATION OF SOIL SURVEY DATA

by

TAKASHI KOSAKI

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T.K.

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PART I

Computer-based Soil Data Management System

(COSMAS)

CHAPTER 1 Research Needs for Soil Information System

During the last decade some soil scientists attempted to develop soil data banks by using a computer (John *et al.*, 1972a, b; Rudeforth, 1975; Lee *et al.*, 1976; Haantjens *et al.*, 1975a,b, c). The motivations were: first, the amount of soil data obtained from projects for soil surveys is rapidly increasing and its efficient management is desired; secondly, those data are expected to serve many people in various fields of study such as agriculture, land use planning and so forth; thirdly, the computer has become a very easy and popular tool to handle.

In 1975 the first international meeting for "Soil Information Systems" was held in Wageningen, Holland. Two additional meetings were held in Australia and Bulgaria, and the papers presented at these meetings were published in "Soil Information Systems" (Bie, 1975), "Uses of Soil Information Systems" (Moore and Bie, 1976) and "Developments in Soil Information Systems" (Sadovski and Bie, 1977). Soil Information System (SIS) naturally contributes to pedological and edaphological studies, but the most important role of SIS, as Dumanski pointed out (Dumanski, 1978), is data management service. At present, a few SISs have been established in Canada, the Netherlands, the U.S.A., Australia, France and West Germany (Dumanski *et al.*, 1975; McCormack *et al.*,1978). Bulgaria, Rumania, U.S.S.R. and other east-European countries also have their own SISs, whose main aims are crop monitoring and optimizing production factors (Garbouchev *et al.*, 1978). When compared to the previous soil data bank's data management, analysis, representation and system manipulation, it is obvious that both types of SIS have been greatly improved.

Normally, all the survey data are rounded into a soil map by an experienced surveyor and then all the interpretation maps are derived from the soil map. However, data should be rounded only in the step of interpretation, but not in the step of compilation of a soil map. In the author's view, a soil map is no more than one of the output forms of the stored data, not the sole base for interpretations. Therefore, the construction of a data bank containing raw soil data obtained in both field and laboratory with an effective management system is highly desired. The author has started a study of the methodology and practical use of a soil data management system. It should be noted here that the purpose of the construction of the system is to provide a convenient tool for general data management for a wide range of users, not to provide a special data bank for a certain research project.

Aiming at an efficient utilization of soil survey data, the author experimentally built up a Soil Information System, named as Computer-based Soil Data Management System (COSMAS), so as to meet the following points;

1. The same descriptive terms should be employed when describing similar features in taking the field record of a soil survey. The irreducible minimum of the description should be taken and stored regardless of the surveyor's intention or purpose of the survey.
2. Computer manipulation for soil data handling sould be easy for anyone who wants the data.
3. A cartographic unit should be included for the graphic representation of the raw and processed data in a base map.

The author will detail the structure and functions of COSMAS in the following two chapters and describe in Part II how COSMAS helps us to perform data retrieval and analysis for practical use of soil data for agriculture.

CHAPTER 2 Collection, Storage and Retrieval of Soil Survey Data

2.1 Introduction

In order to satisfy the requirements of a soil information system as mentioned in Chapter 1, first of all, a procedure of data collection must be established with defined terminology. Many methods of data collection are already known, such as field notebook, marksense card, punch card, voice recorder and so on. Among these various methods a standardized description card is best fitted to field survey, provided it is well organized, because it is simple to fill out, easy to read and no special equipment is needed (Kloosterman, 1975).

Secondly, the system must be based on a well established data management system so as to satisfy basic requirements of data retrieval. In addition, the system is desired to involve the functions of data analysis, that is, statistical analysis, when aiming at an efficient use of the bulk of soil survey data. Simple operation of the system is also highly required, since the system may be used by those who are not specialized in computer manipulation. Therefore, Statistical Package for the Social Sciences(SPSS), which is one of the currently used data management system, is suitable for COSMAS. SPSS carries out general data management and statistical analyses, but does not satisfy a special requirement of soil information retrieval. Then, some separate programs are to be prepared in compensation. For example, it takes considerable time and labor to retrieve site and horizon descriptions and analytical data in text and tabulated forms. Hence, it is necessary to provide an output program for COSMAS for quick and easy retrieval of raw soil data in a conventional form.

2.2 Standardization of Data Collection

2.2.1 Currently used description card

Some people have already designed description cards fitted to their own data banks. Roughly speaking, two types of description card were designed, one by Haantjens _et al._ (1975a,b,c) and Hazelden _et al._ (1976), and the other by Lee _et al._ (1976).

In the description card designed by Hazelden all data are to be written in numerical codes assigned for their system. In this method, a surveyor has to memorize the numerical code corresponding to a field appearance prior to a survey, or check it in the translation table in the field. It is a very troublesome and error-prone procedure. Furthermore, those recorded data are not easily understandable in the laboratory without translation. Since two types of description card, detailed form and short form, are proposed, two different types of data management are needed, and it is complicated for the users to retrieve those data. To avoid complexity in the data processing, it is not advisable to have dual structures for data storage. Some important attributes are missing in Hazelden's system: land form and ground water level, which are among the most improtant keys to understanding or interpreting soils in lowland areas. Haantjens also employed a numerical code method. His method has the same shortcomings as those mentioned above. Moreover, his description card is more bulky and tedious to handle, and is not well organized, because different types of information (for instance, observations obtained in the field and estimates based on laboratory analyses) are assigned to be recorded together on the same pages.

On the other hand, a multiple choice method is employed by Lee. All possible terms are assigned on the card, and a numerical or letter code corresponding to a particular descriptive term is ticked or written in the box. His method is fitted to field use and is very easily understood in the laboratory without any translation. In his system, however, none of the site descriptions is included in the computer-processed system. Some of the site attributes are, of course, very difficult to standardize as specified terms, but it is desirable to select the nearest term corresponding to the actual feature from a set of preselected terms. Otherwise an actual feature may be expressed in many different ways, and the attribute cannot be used for screening of the required features. Topographical data, land form, and land use are often used for screening an area out of a soil map; therefore, those should be included in the system. Furthermore, most of the attributes, including multistate-ranked attributes, are given as numerical or letter codes in the card. When the terms of multistate-unranked attributes are well defined, as in the case of "soil texture", they need not be shown on the card. A letter code such as "SL" for sandy loam can be put on the card to describe a state of soil texture.

2.2.2. Proposed description card for COSMAS

The author designed an improved description card employing a multiple choice system, and letter codes as well as numerical codes. The description card is designed to meet the following points;

1. Possible descriptive terms are given for such attributes except for some whose terms are very familiar to us or which have a large number of state descriptions, such as soil texture. Furukawa (1979) defined all possible terms, from which a surveyor can choose the one most nearly corresponding to the actual feature. He also defined their letter codes, which are to be written on the card. Surveyors have no difficulty in learning the code for each

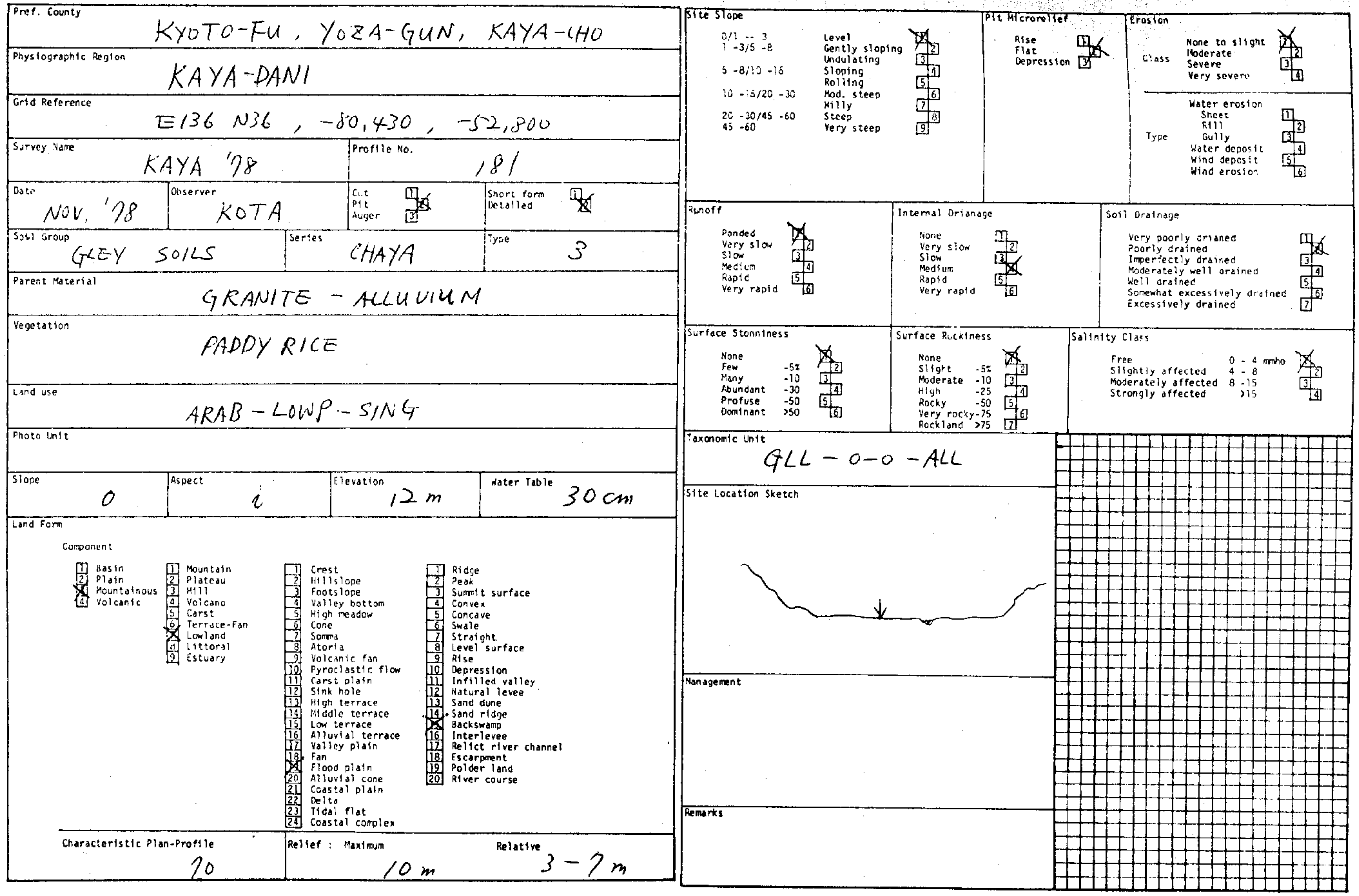
attribute prior to field work or checking it on a translation table in the field. The data obtained in this manner are easily understandable not only in the field but also in the laboratory.

2. Numerical codes are given for the multistate-ranked attributes (e.g. stone abundance). These are ticked or written in assigned boxes.
3. Scaled attributes are measured with appropriate apparatuses and their readings are written in the boxes in assigned units (e.g. ground water level (cm)).
4. Letter codes are standardized to express the multistate-unranked attributes. These are very familiar to us, and easier to use and clearer to understand than numerical codes.
5. For missing records, "999" and blank are assigned to the numerical code and letter code, respectively. Likewise, for irrelevant records such as "mottle size" and "mottle color" for soil without mottles, "0" (zero) and "i" are given.

The given terms are assigned to fit mainly the conditions of Japan and Southeast Asian countries. It may take 15 to 20 minutes to fill out the description card for one profile. The front and back sides of the card are used for site description and horizon description,respectively, as shown in Figure 2-1.

2.3 Data Management

SPSS (Statistical Package for the Social Sciences) was employed for data management. SPSS is one of the program packages that are adapted to the FACOM M-200 computer in the Kyoto University Data Processing Center, and includes many subprograms not


Pref. County: KYOTO-FU, YOZA-GUN, KAYA-CHO

Physiographic Region: KAYA-DANI

Grid Reference: E136 N36, -80,430, -52,800

Survey Name: KAYA '78 | Profile No.: 181

Date: NOV. '78 | Observer: KOTA | Cut 1, Pit 2, Auger 3 | Short form 1, Detailed 2

Soil Group: GLEY SOILS | Series: CHAYA | Type: 3

Parent Material: GRANITE - ALLUVIUM

Vegetation: PADDY RICE

Land use: ARAB - LOWP - SING

Photo Unit

Slope: 0 | Aspect: i | Elevation: 12 m | Water Table: 30 cm

Land Form

Component: 1 Basin, 2 Plain, 3 Mountainous, 4 Volcanic

1 Mountain, 2 Plateau, 3 Hill, 4 Volcano, 5 Carst, 6 Terrace-Fan, 7 Lowland, 8 Littoral, 9 Estuary

1 Crest, 2 Hillslope, 3 Footslope, 4 Valley bottom, 5 High meadow, 6 Cone, 7 Somma, 8 Atoria, 9 Volcanic fan, 10 Pyroclastic flow, 11 Carst plain, 12 Sink hole, 13 High terrace, 14 Middle terrace, 15 Low terrace, 16 Alluvial terrace, 17 Valley plain, 18 Fan, 19 Flood plain, 20 Alluvial cone, 21 Coastal plain, 22 Delta, 23 Tidal flat, 24 Coastal complex

1 Ridge, 2 Peak, 3 Summit surface, 4 Convex, 5 Concave, 6 Swale, 7 Straight, 8 Level surface, 9 Rise, 10 Depression, 11 Infilled valley, 12 Natural levee, 13 Sand dune, 14 Sand ridge, 15 Backswamp, 16 Interlevee, 17 Relict river channel, 18 Escarpment, 19 Polder land, 20 River course

Characteristic Plan-Profile: 70 | Relief : Maximum 10 m | Relative 3 - 7 m

Site Slope: 0/1 -- 3, 1 -3/5 -8, 5 -8/10 -16, 10 -15/20 -30, 20 -30/45 -60, 45 -60 | 1 Level, 2 Gently sloping, 3 Undulating, 4 Sloping, 5 Rolling, 6 Mod. steep, 7 Hilly, 8 Steep, 9 Very steep

Pit Microrelief: 1 Rise, 2 Flat, 3 Depression

Erosion — Class: 1 None to slight, 2 Moderate, 3 Severe, 4 Very severe; Type: Water erosion 1 Sheet, 2 Rill, 3 Gully, 4 Water deposit, 5 Wind deposit, 6 Wind erosion

Runoff: 1 Ponded, 2 Very slow, 3 Slow, 4 Medium, 5 Rapid, 6 Very rapid

Internal Drianage: 1 None, 2 Very slow, 3 Slow, 4 Medium, 5 Rapid, 6 Very rapid

Soil Drainage: 1 Very poorly drianed, 2 Poorly drained, 3 Imperfectly drained, 4 Moderately well drained, 5 Well drained, 6 Somewhat excessively drained, 7 Excessively drained

Surface Stonniness: 1 None, 2 Few -5%, 3 Many -10, 4 Abundant -30, 5 Profuse -50, 6 Dominant >50

Surface Rockiness: 1 None, 2 Slight -5%, 3 Moderate -10, 4 High -25, 5 Rocky -50, 6 Very rocky-75, 7 Rockland >75

Salinity Class: 1 Free 0 - 4 mmho, 2 Slightly affected 4 - 8, 3 Moderately affected 8 -15, 4 Strongly affected >15

Taxonomic Unit: GLL - 0-0 - ALL

Site Location Sketch

Management

Remarks

Fig. 2-1 Standardized description card (front)

Pref. County	KYOTO, YOZA	Survey	KAYA '78	Profile No.	181

Item	Options	1	2	3
HORIZON NO.		1	2	3
HORIZON NAME		A1p	GR	GR
THICKNESS cm		15	11	13+
BLEACHING	1 2 3 4 5 6	1	1	1
ACCUMULATION Material		1	1	1
ACCUMULATION Class	1 2 3 4	1	1	1
BOUNDARY Distinct. /Shape	1 abrupt-2cm 2 clear -5 3 gradual-12 4 diffuse≥12 / 1 smooth 2 wavy 3 irregular 4 broken	1/1	1/1	
COLOR		7.5Y 5/1	5GY 4/1	10Y 5/1
MOISTURE	1 dry 2 moist 3 wet 4 v.wet 5 x.wet	4	4	3
TEXTURE		CL	CL	SL
MOTTLE /CUTAN M. Shape		film	film	tube
MOTTLE /CUTAN C. Nature		1	1	1
MOTTLE /CUTAN Distinct. /Surface	1 faint 2 distinct 3 prominent / 1 grain 2 ped 3 void	2/0	2/0	1/0
MOTTLE /CUTAN Size /Thickness	1 fine -5mm 2 medium-15 3 coarse>15 / 1 thin 2 mod. 3 thick	2/0	2/0	1/0
MOTTLE /CUTAN Abundance	1 none 2 few -5% 3 many -10 4 abund-30 5 profu.>30 / 1 none 2 patchy 3 broken 4 continu.	3/1	2/1	2/1
MOTTLE /CUTAN M.Color		10YR 5/6	7.5YR 5/8	7.5YR 5/8
MOTTLE /CUTAN C.Color		1	1	1
O.M. Content	1 low -2% 2 medium -5 3 high -10 4 v.high -20 5 x.high >20	2	1	1
O.M. Form/Decomposition				
STONE Abundance	D: 1 none 2 few -5% 3 many -10 4 abund.-30 5 profu.-50 6 domin.>50 / S: 1 none 2 few 3 many 4 abund. 5 profu. 6 domin.	1	1	1
STONE Size	1 gravel -6mm 2 s.pebble-25 3 pebble -64 4 cobble -256 5 boulder>256 / 1 gravel 2 s.p. 3 p. 4 c. 5 b.	0	0	0
STONE Weathering	1 none 2 slightly 3 mod. 4 strongly / 1 none 2 slightly 3 mod. 4 strongly	0	0	0
STONE Shape		1	1	1
STONE Type		1	1	1

Soil Group	GLEY	Land Use	LOWLAND PADDY	Grid Reference	-80,430, -52,600

Item	Options	1	2	3
MINERAL Abund./Type		QM	Q.M	Q.M
FERROUS Class	1 2 3 4	1	4	4
COMPACTNESS	1 loose 2 penetrable 3 deep finger print 4 shallow f.p. 5 no f.p. 6 knife	2	4	4
COMPACTNESS Penetromtr. mm/kg cm^{-3}		8	20	18
PERMEABILITY kg cm^{-2}		999	999	999
STRUCTURE Grade	D: 1 massive 2 S.G. 3 weak 4 moderate 5 strong / S: 1 massive 2 S.G. 3 weak 4 moderate 5 strong	1	1	1
STRUCTURE Size	1 v.fine 2 fine 3 med. 4 coarse 5 v.coarse / 1 v.fine 2 fine 3 med. 4 coarse 5 v.coarse	0	0	0
STRUCTURE Type	1 platy 2 prismatic 3 columnar 4 blocky 5 nutty 6 granular 7 crumb / 1 platy 2 prismatic 3 columnar 4 blocky 5 nutty 6 granular 7 crumb	0	0	0
CONSISTENCE Moist/Dry	1 loose 2 v.friable 3 friable 4 firm 5 v.firm 6 x.firm / 1 loose 2 soft 3 sl.hard 4 hard 5 v.hard 6 x.hard	3/3	3/4	3/999
CONSISTENCE Sticky /Plastic	1 non-sticky 2 sl.sticky 3 sticky 4 v.sticky / 1 non-plast 2 sl.plast. 3 plastic 4 v.plastic	2/2	2/3	1/1
POROSITY Intrapedal /Interpedal	1 f.porous-1mm 2 porous-3 3 spongy-5 4 cavern.-10 / 1 f.fiss. 2 fissur. 3 w.fiss. 4 v.w.f. 5 x.w.f.	999	999	999
ROOTS Abundance	1 none 2 few 3 many 4 abundant 5 root mat	3	2	1
ROOTS Type /Distri.	1 evergreen 2 decid. 3 grass 4 others / 1 horizont. 2 vertical 3 oblique 4 ubiq.	3/4	3/2	0/0
FABRIC	1 earthy 2 sandy 3 rough 4 sm.	1	1	2
PANS Cementation	1 none 2 weak 3 str 4 ind.	1	1	1
PANS Structure		1	1	1
SECONDARY FORMATION Abund.	1 2 3 4 5 6	1	1	1
SECONDARY FORMATION Type/Comp.		1	1	1
SAMPLE Bag		0	0	
SAMPLE Core		K232	K233	

Fig. 2-1 (cont'd) Standardized description card (back) only for data storage and retrieval management but also for statistical analyses such as regression analysis, factor analysis and so on (Nie et al., 1975; Miyake and Yamamoto, 1977).

There have been some studies of soil data banks as mentioned before. They included data management programs such as input, screening and retrieval procedures, but not programs for statistical analyses. Statistical analayses have to be used when handling a large number of soil data. The data, if they are retrieved only in the form of a numerical or letter code and figures of measurements, are almost useless to the users. The larger the number of data, the more difficult they are to comprehend. Therefore, the system should be provided with some means to handle a huge data matrix; that is, statistical programs. This is one of the reasons why SPSS was introduced to COSMAS. Secondly, SPSS has remarkably developed functions of file management which is very important in natural sciences as well as in social sciences. And finally, SPSS is very easy to use even for those who are unfamiliar with a computer. A few control cards and task cards can command any job steps such as data storage, selection, conversion, and so on.

Some of the well-established soil information systems are also based on some kinds of program packages for data management and processing. For instance, "G-EXEC," "GRASP," "SYMAP" and "SPSS" were introduced by the Dutch (Bie, 1977) and a German group (Lamp, pers. comm.). CanSIS was based on "RAPID" for its data management (Kloosterman, pers. comm.). The fundamental structure and data flow of COSMAS is shown in Figure 2-2 and detailed in the following. The management of the polygon data stored in the cartographic file will be described in the following chapter.

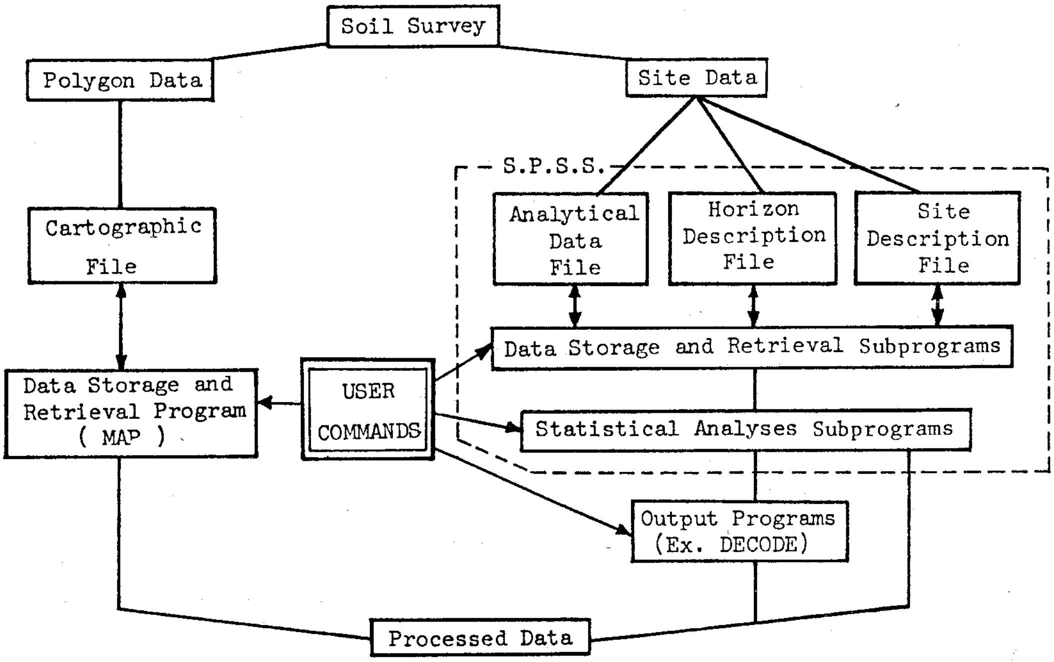


Fig. 2-2 Fundamental structure and data flow in COSMAS

2.3.1 Input

All description data including letter code and numerical code are put into files through 80-column punch cards or a time sharing system without any translation between the description card and data input.

Analytical data are also put into a file as scaled attributes. At present, analytical data include pH (H_2O and 1N KCl), exchangeable cations (Na^+, K^+, Ca^{2+} and Mg^{2+}), cation exchange capacity, organic carbon content, total nitrogen content, total phosphorus, phosphorus absorption coefficient, available phosphorus, available silica, free oxides (Fe_2O_3, MnO_2, Al_2O_3), sand content, silt content, clay content, C/N ratio, percent base saturation, bulk density, particle density, porosity, water content and water saturation percentage. The file is still large enough in its capacity to accommodate additional attributes.

For each input, COSMAS requires two 80-column punch cards of site description, two of horizon description and two of analytical data for each horizon. The COSMAS file system normally has the capacity for six horizons of description and analytical data. Therefore, dummy data should be put into the files when the total number of horizons is less than six. Free format or fixed format can be chosen by the users for input. The data must be thoroughly checked for errors prior to storage in the files.

2.3.2 Storage and retrieval

Three SPSS files are ready to store the data mentioned above. They are the Site Description File which includes the data recorded on the front side of the description card, the Horizon Description File which consists of the data written on the back side of the description card, and the Analytical Data File composed of physical and chemical data obtained in the laboratory analyses. Although the data are stored in the three files separately, all of them can be cross-referenced with one another. Therefore, no problems will arise when the data, stored in three different files, simultaneously undergo processing.

All the data are stored in exactly the same form as those written on the field description card. They can be transformed into the forms favorable for expected manipulation by SPSS. For example, subprogram "RECODE" can transform a letter code into a numerical code or *vice versa*, a numerical value into a numerical code by designating threshold values, and so on. Subprogram "COMPUTE" can make up a new series of data from existing data. For example, porosity, water saturation, moisture content and particle density of soils can be calculated from the data of three phase distribution and bulk density and added to the file in existence. Subprogram "SELECT IF" is used for data screening. Any logical requirement can be given to the system according to the users' interests. For instance, the combination of subprograms "SELECT IF" and "LIST CASES" is capable of data extraction from 500 cases (profiles) based on such a requirement as "Give all the profile descriptions of the profile whose soil type is Brown Lowland Soil," when those two subprograms are specified as follows;

```
{ SELECT IF        (TU1* EQ "BLS**")
{ LIST CASES       CASES=500/VARIABLES=ALL
```

* "TU1" is the abbreviated form assigned to a soil attribute "Taxonomic unit 1 (soil type)."

** "BLS" is the abbreviated form assigned to "Brown Lowland Soil."

Subprogram "MERGE FILES" takes up all or some of the attributes in the individual files to build up a new file so that it may undergo further processing. Soil data can be handled easily and efficiently with the help of various combinations of the functions of the SPSS data management system.

2.3.3 Output

2.3.3.1 Statistics

SPSS has many statistical subprograms whose output formats are inherently fixed. Some commonly used subprograms are briefly described in the following.

Subprogram "CONDESCRIPTIVE" produces statistics such as a mean, standard deviation, standard error, variance, kurtosis, skewness, range, maximum and minimum. Subprogram "FREQUENCIES" generates histograms from data values with the statistics mentioned above. Subprogram "SCATTERGRAM" and "TRIANGRAM" produce scattergrams from the data of any two and three attributes, respectively, together with some statistics such as correlation coefficient. Subprogram "REGRESSION" carries out multiple regression analysis and subprogram "ANOVA" executes the analysis of variance. Factor analysis and cluster analysis can be done with subprograms "FACTOR" and "CLUSTER", respectively.

2.3.3.2. "DECODE" program

This program was prepared to translate stored data in coded forms into a conventional text. The output is readily published as a part of soil survey report. The program was written in FORTRAN and is now available as a library program open to anyone who wants to use it. Users are able to get full descriptions of site and horizon characteristics, as well as analytical data for the profiles that interest them through this program. It sets us free from the time-consuming and error-prone job of preparing of soil profile description and the tabulation of analytical data. Figure 2-3 shows the output from the "DECODE" program. The details of this program and the user manual are given in the reference material (Laboratory of Soil Science, Kyoto University, 1981).

2.4 Discussion

The main purpose of this pilot study of a soil information system is to work out and test the methodology by which the system is created and handled. Therefore, the format of the input and output may be modified, if necessary. However, the fundamental structure of COSMAS will be maintained even if COSMAS undergoes

```
                              LABORATORY OF SOILS

                     DEPARTMENT OF AGRIC. CHEM. , KYOTO UNIV.
                          SAKYO-KU,KYOTO 606, JAPAN

* PREFECTURE,COUNTY        ;  KYOTO-FU,YOZA-GUN,KAYA-CHO

* PHYSIOGRAPHIC REGION     ;  KAYA-DANI

* SURVEY                   ;NAME(  KAYA'78      )   DATE(NOV.'78 )  OBSERVER(  KOTA  )

* PROFILE NO.              ;  181

* TYPE OF PROFILE          ;      PIT

* TYPE OF DESCRIPTION      ;    DETAILED

* PARENT MATERIAL          ;

* LAND USE                 ;      ARABLE    -     LOWLAND PADDY     -       SINGLE

* LAND FORM                ;    MOUNTAINOUS  -   LOWLAND    -    FLOOD PLAIN

* TOPOGRAPHICAL DATA       ;  SLOPE            ASPECT            ELEVATION        WATER TABLE
                                 0 DEGREE                             8 M             30 CM

* EROSION                  ;  CLASS                              TYPE
                                NONE TO SLIGHT

* DRAINAGE                 ;  RUNOFF           INTERNAL          SOIL DRANAGE
                                PONDED              SLOW                  POORLY      DRAINED

* TAXONOMIC UNIT,          ;    GLL  -  0  -  0  -  ALL

1     A1 ( 15CM )      7.5Y 5/1 ; V.WET   ;   CLAY LOAM   ; MEDIUM  ORGANIC MATTER CONTENT
                    MASSIV   STRUCTURE ,
                    MANY     MEDIUM  DISTINCT MOTTLE (   10YR 5/6)
                    FRIABLE (SL.HARD WHEN DRY) , SLIGHTLY STICKY , SLIGHTLY PLASTIC
                    COMPACTNESS - FINGER PENETRABLE    ,    8 MM CONE PENETRATION
                    MANY       UBIQUITOUS ROOTS OF      GRASS
                    ABRUPT    SMOOTH    BOUNDARY ;

2     GR ( 11CM )       5GY 4/1 ; V.WET   ;   CLAY LOAM   ; LOW     ORGANIC MATTER CONTENT
                    MASSIV   STRUCTURE ,
                    FEW      MEDIUM  DISTINCT MOTTLE (  7.5YR 5/8)
                    FRIABLE (HARD    WHEN DRY) , SLIGHTLY STICKY , MODERAT. PLASTIC
                    COMPACTNESS - SHALLOW FINGER-PRINT ,   20 MM CONE PENETRATION
                    FEW       VERTICAL    ROOTS OF      GRASS
                    FERROUS ION COLOR IS IMMEDIAT APPEARED ;
                    ABRUPT    SMOOTH    BOUNDARY ;

3     GR ( 13CM+)       10Y 5/1 ; WET     ;   SANDY LOAM  ; LOW     ORGANIC MATTER CONTENT

                    MASSIV   STRUCTURE ,
                    FEW      FINE     FAINT    MOTTLE (  7.5YR 5/8)
                    FRIABLE                    , NON-     STICKY , NON-    PLASTIC
                    COMPACTNESS - SHALLOW FINGER-PRINT ,   18 MM CONE PENETRATION
                    FERROUS ION COLOR IS IMMEDIAT APPEARED ;
```

```
                         ************CHEMICAL  DATA************

        -----PH-----   -----------EXTR.BASES-----------        BASE   -----------TOTAL-----------    P205
HOR       H2O    KCL     K      NA      CA      MG     SUM    CEC   -SAT.     C        N      C/N    P205   -ABS.

                       <-------------MEQ/100GSOIL------------->    <---------%--------->         <--MG/100GSOIL-->

 1.  I   5.80   4.80   0.57   0.12   4.78   1.69   7.16   13.31   53.8     2.52   0.238   10.58   103.0********
 2.  I   5.20   4.40   0.19   0.15   3.28   1.12   4.74   12.38   38.3*****************************************
 3.  I*******************************************************************************************************


        AV.     AV.      ------FREE OXIDES------
HOR     P205    SIO2       MNO2   FE2O3   AL2O3

      <-MG/100GSOIL->    <----------%---------->

 1.  I  51.940  23.330    0.021   3.243   0.920
 2.  I***************   ***********************
 3.  I***************   ***********************


                         ************PHYSICAL  DATA************

        BULK    PART.   H2O             H2O      -----MECHANICAL ANALYSIS-----
HOR     -DENS.  -DENS.  -CONT.   PORE   -SAT.  C.SAND  F.SAND   SILT   CLAY    TEXT

                        <-----------------------%----------------------->

 1.  I    0.84    2.46    72.7   65.8   92.9********************************   ****
 2.  I    1.34    2.52    34.6   47.0   98.5********************************   ****
 3.  I***********************************************************************   ****
```

Fig. 2-3 Output by "DECODE" program

minor modifications in the future. The followings were accomplished in this study:

1. standardization of the profile description card and terminology, and
2. construction of a data management system.

The standardized description card enables us to understand and describe soil characteristics in a soil survey using the terminology defined by Furukawa. The data can be clearly understood and easily utilized by a large number of potential users who are not specialists in the soil survey field. However, the terminology put forward in this paper for COSMAS has not been accepted unanimously, and it will have to be modified when a standard terminology is defined for a nation-wide system of soil information.

Recently developed soil information systems are, to some extent, based on currently used data base management systems. SPSS was introduced to COSMAS for data management and analyses, first because of the provision of statistical subprograms, and secondly because of its ease of use for those unfamiliar with a computer. SPSS has been developed for general use for data management and statistical analyses; therefore it does not always satisfy a large variety of the output requirements of a soil information system. In order to meet special output requirements, the author provided additional programs, one of which is "DECODE." This program cooperates with SPSS and generates profile description and tabulation of the analytical data, thus saving a great deal of time and labor.

CHAPTER 3 Graphic Representation of Soil Survey Data

3.1 Introduction

Soil information is almost always retrieved in map form for practical use. Generally speaking, an interpretation map must be prepared for an individual problem in agriculture, land use planning, etc., to present the results of the analysis of stored data. Also in the field of research, soil information, especially when it consists of a large number of data, is easier to understand, when it is represented as a map or graph. However, it is well known that the production of a map requires considerable time and labor, and the compilation of a special purpose map even more.

A modern soil information system must, therefore, be provided with an automatic cartographic unit to satisfy the needs mentioned above. COSMAS's automatic cartographic unit has the following three objectives (Zuijlen, 1975):

1. to speed up production of maps,
2. to reduce cost, and
3. to allow production of special purpose maps.

Two types of data may be obtained in a soil survey: site data and polygon data. The former include geographical and geological descriptions and soil morphological features of each horizon at the observation sites. The latter include the data which are obtained as an area delineated on thematic maps such as an air-photo interpretation map, cadastral map and others which are prepared in a conventional way. The author has already described the procedure for management and retrieval of site data in Chapter 2. In this chapter, a method of graphical representation of stored data, including both site and polygon data, will be described.

Many papers have been published on the graphical representation of soil survey data. Procedures for digitization, storage and retrieval of polygon data and their attributes were proposed by Johnson (1977) and Sykes and Petersen (1980). Other soil information systems employ an elementary cell as a data unit which is characterized by many soil attributes (Webster and Burrough, 1972a,b; Nichols, 1975; Cormack, 1976; Beeren, 1977; Legros and Hensel, 1977; Ragg, 1977; Tilman and Mokma, 1980). In these methods, the data must be considered homogeneous in a given polygon or unit cell. The distribution of data is, however, not as simple as mentioned above, hence, the site data and the polygon data should be stored in separate files and retrieved as required. Furthermore, the unit cell storage method requires huge amounts of storage space, therefore it is better suited for a regional information system, but not for a large, nation-wide information system.

Cameron and Toogood (1970) employed site data to extrapolate a two-dimensional representation to show the distribution pattern of the required attributes. The application of this method is considered to be restricted to certain soil attributes, which are scaled or multistate-ranked ones. Bie *et al*. (1978) reported the procedure of compilation of an interpretation map based on a combination of site data and polygon data introducing the discrete approach method by de Gruijter and Bie (1975). It is useful in the map compilation stage to divide the area into elementary cells for the logical overlay of some given attributes as Bie *et al*. showed.

Site and polygon data should be stored and managed in separate files to facilitate combination of those data as needed. COSMAS gives priority to the polygon data for the compilation of special purpose maps, provided the polygon is considered homogeneous on the attribute concerned. When the polygon does not prove so, site data are used for the preparation of the map. This is the author's philosophy for the preparation of a special purpose map

Four of the programs, which were completed for automatic cartography in order to facilitate graphical representation of two types of data, will be described in the following part. The data used here were obtained in a detailed soil survey of Kaya Township, Kyoto Prefecture. Samples were taken at an average density of one per every four hectares.

3.2 Data Input

3.2.1 Location of a sampling site

Each sampling site is marked on a base map when it is observed in the field. The location is then stored as grid reference in the COSMAS Site File mentioned in Chapter 2. A grid reference is described relative to a given geodetic point, measured in kilometers northward and eastward from that point. In the Kinki District of Japan, where Kyoto is located, a geodetic point (E136 N36) is used in describing the locations. A negative sign is assigned to southward and westward shifts. For example:

E136 N36, -153.254, 009.080

It is a time-comsuming and error-prone job to get a grid reference for a sampling site on the base map by means of the scale. "TABLET", which is a digitizer connected to the FACOM M-200 computer of Kyoto University Data Processing Center, is employed to record the grid references of the sampling sites. The base map, on which each sampling site is marked, is placed on TABLET, and an attached cursor or stylus is moved to touch the mark on the map, thereby the location of the site being digitized in an X,Y-coordinate system with a given origin.

3.2.2 Polygon data

Polygon data consist of boundaries and attributes of all delineated areas within a map. A boundary is recorded as segments, each of which is defined by identification numbers of such points as nodes and inflection points, and identification numbers of the areas that are delineated by the segment. As shown in Figure 3-1, area 1 is delineated by a boundary which is composed of three segments; S1, S2 and S3. Segment S1 is defined by an initiating node (N1), a terminating node (N2), an initiating inflection point (I1), a terminating inflection point (I3) and identification numbers of the areas (1 and 3). Likewise, the other segments (S2, S3, S4,...) are defined by those data as shown in Table 3-1.

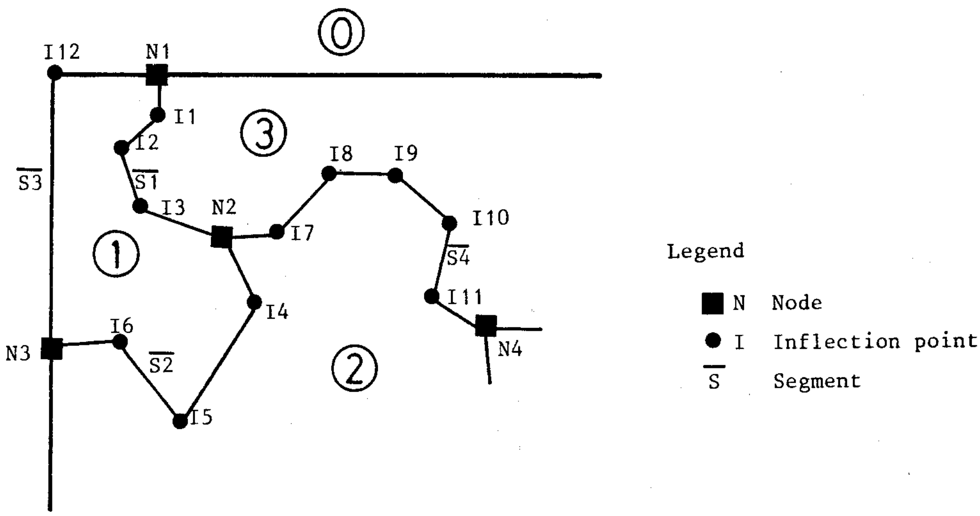


Fig. 3-1 Schematic model of polygon data

The location of nodes and inflection points is recorded in a form of a grid reference by means of TABLET in the same manner as the ones of sampling site. Attributes of a delineated area are recorded for each of the mapping units. Table 3-2 shows

Table 3-1 Segment definition

Segment No.	Node No. init.	Node No. term.	Inflection point No. init.	Inflection point No. term.	Area Identification	
1	1	2	1	3	1	3
2	2	3	4	6	1	2
3	1	3	12	12	1	0
4	2	4	7	11	2	3
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.

Table 3-2 Soil attribute list

Mapping Unit No.	Soil Type	Soil Variety	Physiographic Unit	Texture	Stoniness	Slope
1	GLL	ALL	FP	F		FLAT
1	GRL	UG	FP	M		FLAT
2	GRL	ALL	FP	M		FLAT
3	GLL	ALL	FP	M		FLAT
4	GRL	ALL	FAN	C		G.SL
10	GRL	ALL	VP	M	PM	ROL
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.

Abbreviations

Soil Type : GLL(gley lowland soil), GRL(gray lowland soil)
Soil Variety: ALL(all horizon), UG(underground gley), RG(reverse gley)
Physiographic unit: FP(flood plain), VP(valley plain), FAN(fan)
Texture : F(fine), M(medium), C(coarse)
Stoniness : PM(pebble many)
Slope : FLAT(flat), G.SL(gently sloping), ROL(rolling)

a part of an attribute list of a soil map compiled by a conventional way. Mapping unit (1), which has two sets of attributes, shows a soil complex. All the data such as segment definitions, locations of the points relevant to the boundary and attributes of a delineated area are stored in the Cartographic File of COSMAS.

3.3 Data Management

Grid references of the sampling sites are stored as one of the attributes of the COSMAS Site File, so that they are under the management of SPSS like any other attributes. The fundamental structure and data flow of COSMAS was described in Chapter 2.

Polygon data are stored in the Cartographic File, which is independent of the other three SPSS files of COSMAS; the Site Description File, Horizon Description File and Analytical Data File. The polygon data can be managed through the output program "MAP" which will be discussed later.

3.4 Output Programs

3.4.1 Program "PLOT"

The program "PLOT" transcribes required data, stored in the COSMAS files, onto their respective locations on a map. What we call a site attribute plotting map shows distribution of the data of one or more attributes. It was formerly a tedious process to transcribe the data one by one from the field notes onto a map. However, with this program, any data can be easily and accurately retrieved and represented. Therefore, every interpretation map can be compiled from the raw data stored in the file, rather than from soil map.

For example, when preparing a soil map, it is, first of all, necessary to show the distribution of such data as soil type, variety, stoniness and texture class in a form of a site attribute plotting map as shown in Figure 3-2. Then, the boundaries are located taking into account the result of air-photo interpretation as well as those site data mentioned above. The soil map and other interpretation maps prepared in that way are stored as polygon data in the Cartographic File of COSMAS.

3.4.2 Program "TRANSECT"

Transect-attribute diagrams are prepared using this program. The change of topography and a given attribute along a transect set by the user's requirement are presented on a graphic display device or X-Y plotter. Two attributes can be selected to show the relationship between them. Transect data is a simple and informative tool in understanding the distribution of soils and can be extended into two dimensions using knowledge of topography of the surroundings, provided the transect is set to include enough variability. However, it used to require great effort to find an informative transect by trial and error. This program features interactive query and response, so that it takes only few seconds to get a diagram for any set of data stored in the COSMAS files. With the help of this program, we now have no trouble in finding the most informative data set for the transect.

Figure 3-3 shows a diagram of the abundance of mottles in the subsoils on the transect from site No. 258 to site No. 40 with soil type data as a reference. Two peaks, which correspond to "many mottles," can be seen at two sites; No. 268 and No. 272. It is easily found out that the feature, "many mottles" in the subsoil, appears in association with Wet Brown Forest Soil (B_F) in the study area.

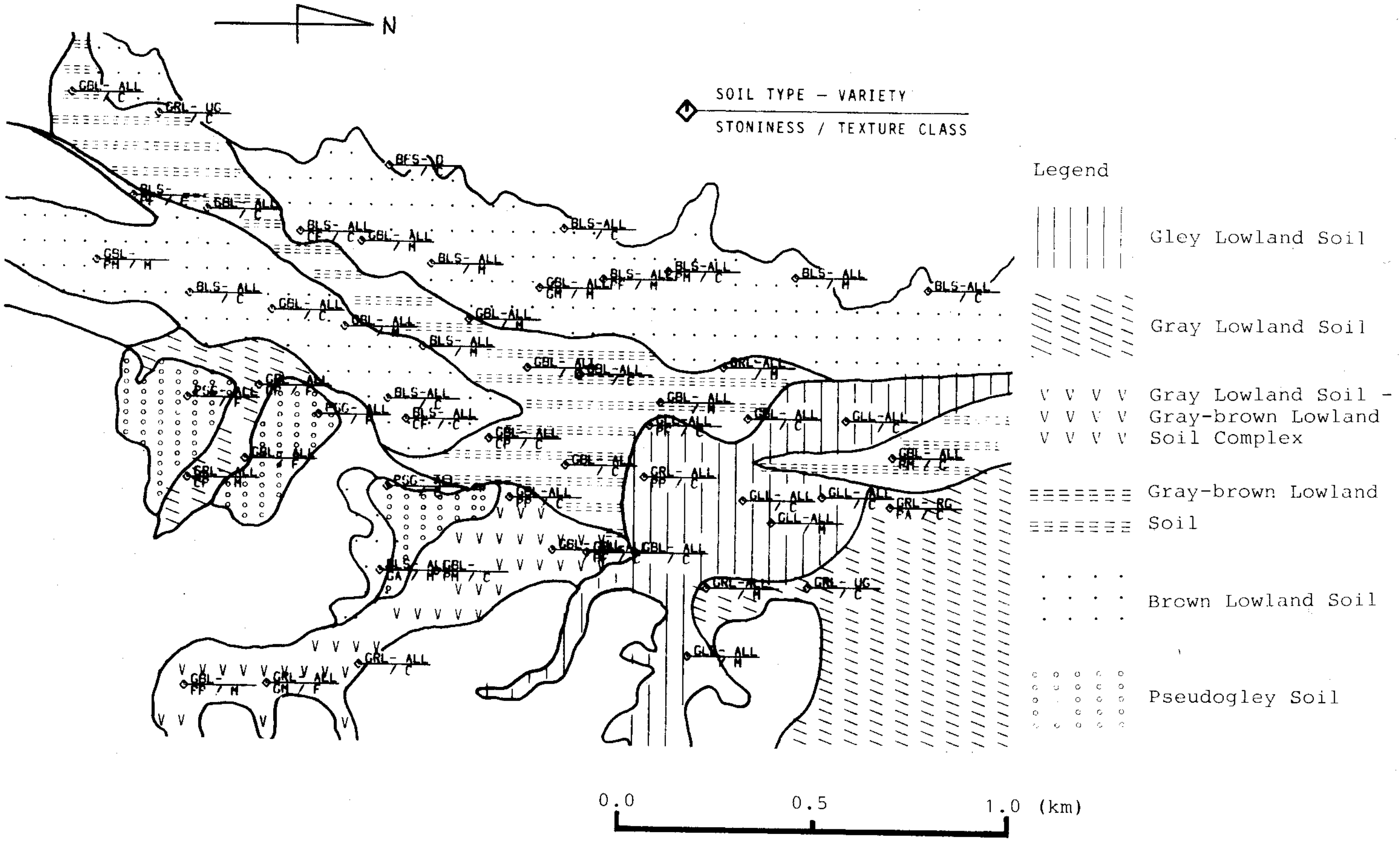
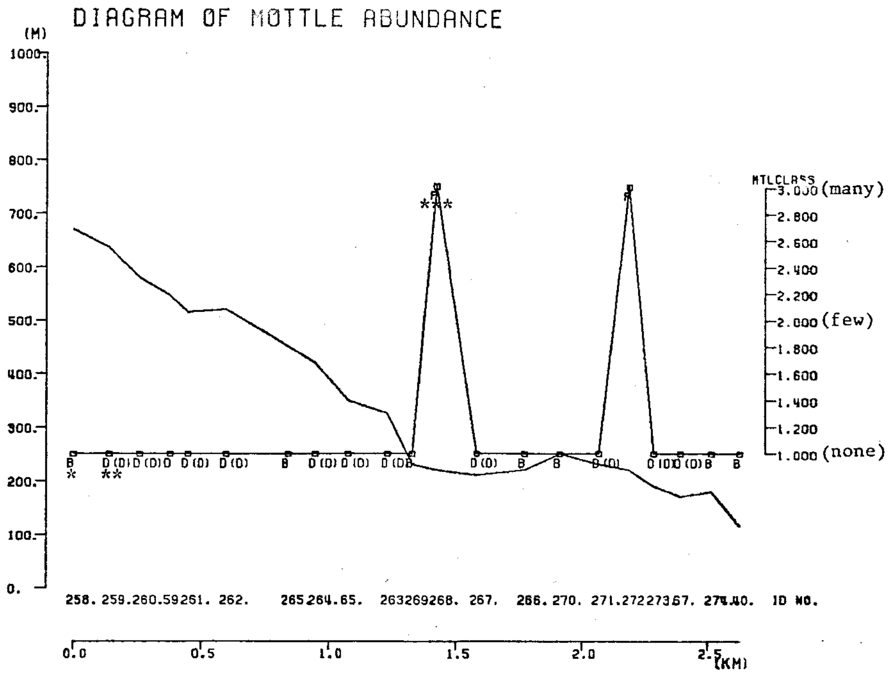


Fig. 3-2 Site attribute plotting map



Soil Type

* : Dry Brown Forest Soil (B_B)

** : Moderately Moist Brown Forest Soil(drier subtype) ($B_{D(d)}$)

*** : Wet Brown Forest Soil (B_F)

Fig. 3-3 Transect-attribute diagram

3.4.3 Program "CONTOUR"

This program carries out the preparation of an isoline map from the data of sampling sites. The users are able to display the isoline map on the graphic display device, X-Y plotter and printer plotter. The first one is used for determining the most appropriate map and the latter two for publication of the final version. An isoline map is prepared for the scaled and multistate-ranked attributes. This program was modified from "SDCONT ," one

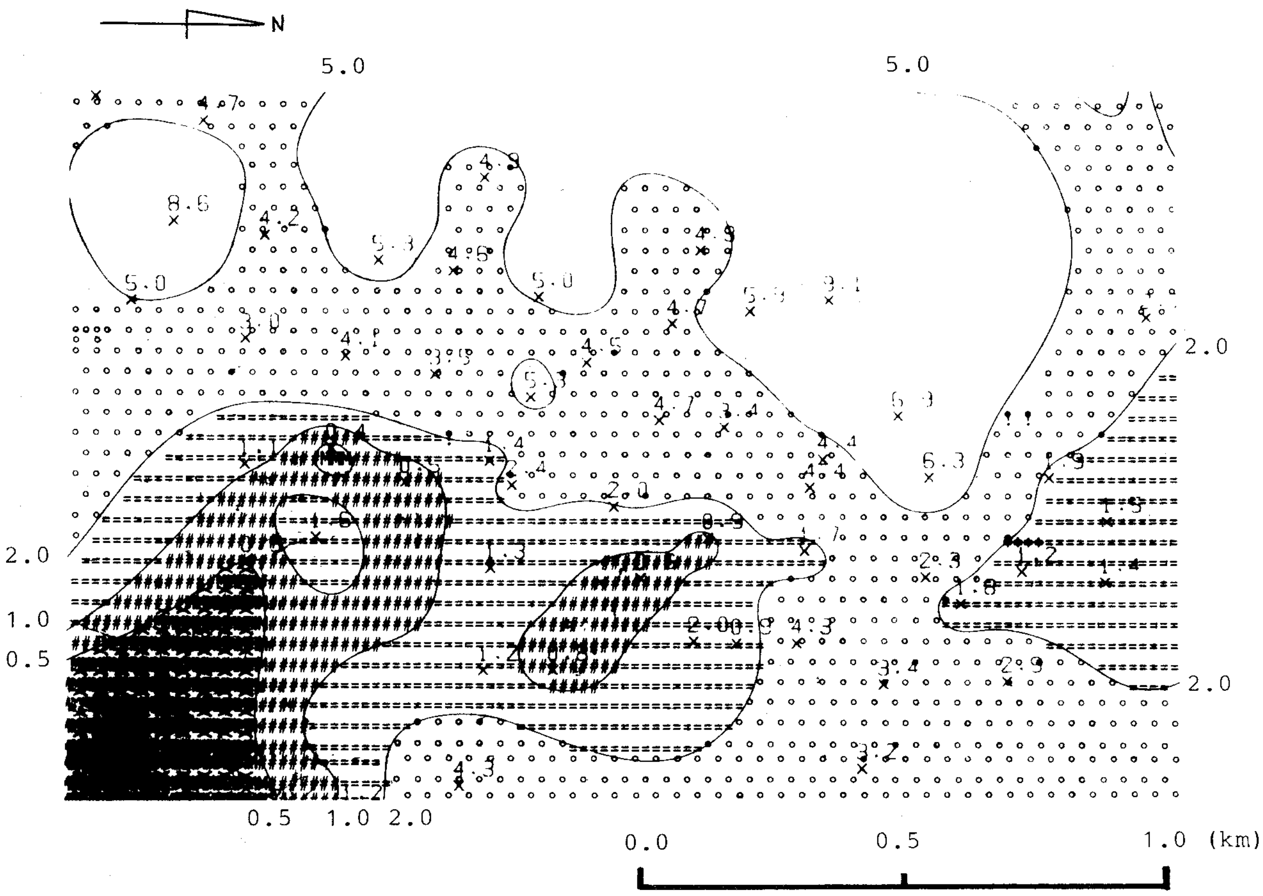


Fig. 3-4 Isoline map based on Ex. Ca/Ex. Mg

of the library subroutines of Kyoto University Data Processing Center, originally written by Fujii (1977). "SDCONT" carries out the computation of a curved surface fitting to the actual values of sampling sites and traces isolines on the surface. The values of isolines are specified by a user.

Figure 3-4 shows the isoline map based on the ratio of the content of exchangeable calcium (Ex. Ca) to that of exchangeable magnesium (Ex. Mg) for the subsoil of the sampling site. The data employed here are stored in the COSMAS Analytical Data File. This figure shows a valley inclined to the right. Geologically, a granite hill and serpentine mountain are located in the upper and lower parts of this figure, respectively. The ratio of Ex. Ca/Ex. Mg is generally lower in the serpentine area than in the granite area. It can be seen in this figure that the low-ratio part, which is represented by darker color, starts from the bottom left side and spreads to the right. It indicates that soil material derived from serpentine, which has low ratio of Ex. Ca/Ex. Mg, came from the mountain, flowed and spread down the valley to the lower part. The distribution pattern of the two different soil materials derived from serpentine and granite can be clearly seen.

3.4.4. Program "AUTOMAP"

This program converts point data to polygon data. Unlike the program "CONTOUR" the program "AUTOMAP" is applicable to the compilation of maps showing a two dimensional distribution of multistate-unranked data.

Figure 3-5 shows the principle of this program. A unit quadrilateral is delineated by connecting four observation sites. For example, when two GLL (Gley Lowland Soil), one GRL (Gray Lowland Soil) and one BLS (Brown Lowland Soil) profiles make up a quadrilateral, and the probabilies* (figures in parentheses), that they belong to their respective classes are designated, as shown in Figure 3-5, there are two alternatives in delineating the areas within the quadrilateral: (A) and (B).

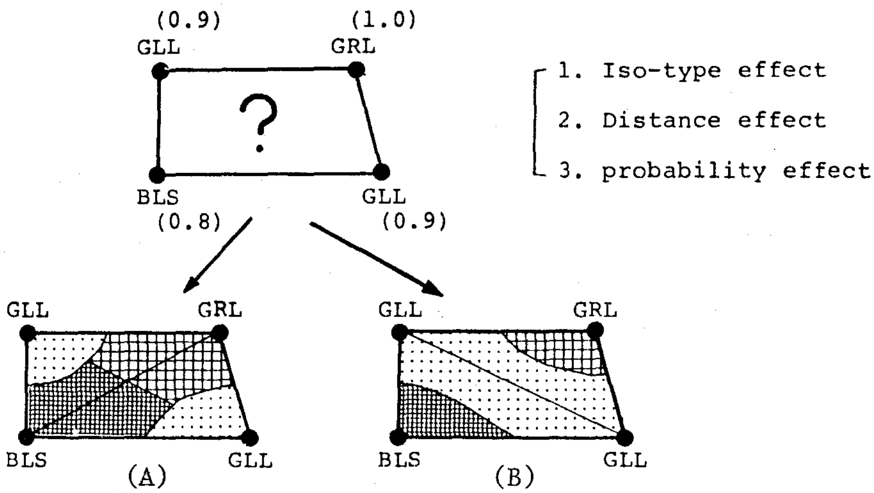


Fig. 3-5 Principle of "AUTOMAP" program

First, the quadrilateral is divided into two unit triangles by selecting one of the two possible diagonals. The following factors are taken into consideration in statistically selecting the more reasonable diagonal;

1. Isotype effect

   A diagonal that connects two sites showing the same characteristics or belonging to the same class is preferred.

* Probability (α) is given in the discriminant analysis ($0.0 \leqq \alpha \leqq 1.0$) that is used for assigning the class to which a sample belongs. In ordinary soil surveys, probability of class assignment by a surveyor is regarded as unity.

2. Distance effect

   A diagonal that has a shorter distance is preferred.

3. Probability effect

   A diagonal that has higher probability (the sum of the probabilities of the two sites) is preferred.

In practice, the diagonal which shows a higher similarity calculated by the following equation is chosen.

$$S = aD + bP + i$$

where,

S : similarity of the two sites that form a diagonal

D : distance ratio (=1.0 or D1/D2, when D1 < D2)
D1, D2 ; length of the diagonals

P : sum of probabilities of two sites

a : coefficient for distance effect

b : coefficient for probability effect

i : coefficient for isotype effect

Coefficients a, b and i must be given by the user to produce a reasonable map for his requirement. They are, however, assigned unities when left unspecified by the user. Coefficient i should be added only when both of the sites which define the diagonal have the same characteristics.

Selection of the more reasonable diagonal is followed by boundary allocation within the unit triangle. A boundary in the unit triangle can be defined by a pair of dividing points that are located on the side whose vertices have different characteristics from each other. The following equation gives the coordinates of the dividing point.

$$D(x,y) = (PR1^2 * L2(x,y) + PR2^2 * L1(x,y)) \ / \ (PR1^2 + PR2^2)$$

where,

D(x,y) : coordinates of a dividing point

L1(x,y), L2(x,y) : coordinates of the vertices

PR1, PR2 : probability of membership in assigned groups for the two vertices

As shown in Figure 3-6, D1, D2 and D4 are found as dividing points. Point D3 is not a dividing point, because two vertices (V1 and V3) have same characteristics. However, the coordinates and probability of D3 must be provisionally determined by the above mentioned equation for defining the dividing point D4. The coordinates of D4 are computed from those and probabilities of V2 and D3. Thus, the segments (D1-D4) and (D4-D2) are registered as boundaries to delineate subareas within the triangle. Likewise, the segments of the boundary must be determined for the other unit triangle. Consequently three subareas are delineated in the quadrilateral and Figure 3-5 (B) is finally obtained.

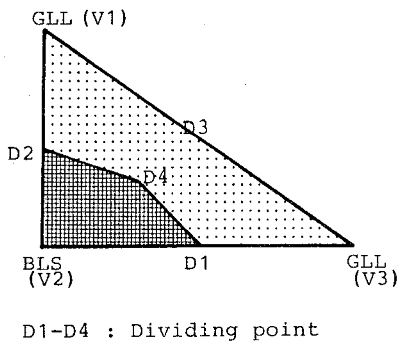


Fig. 3-6 Delineation in a unit triangle

This procedure must be followed for all quadrilaterals concerned, so that the whole area is divided into subareas that are homogeneous with respect to a given soil attribute. The user must predefine the quadrilaterals by the identification numbers of the four sites concerned.

3.4.5 Program "MAP"

This program reproduces a thematic map in full or in part from the polygon data stored in the Cartographic File. Screening of the delineated area can be done with one or more differentiae. Two algorithms of screening are available for multiple differentiae. One is "AND" screening, that is, the data is extracted when it satisfies both condtions "A" and "B." Another is "OR" screening, that is, the data is extracted when it satisfies either condition "A" or "B." The screening and retrieval of delineated areas on the basis of the attribute stored in the Cartographic File are carried out through this program. An interpretation map can be easily prepared from the soil map and other

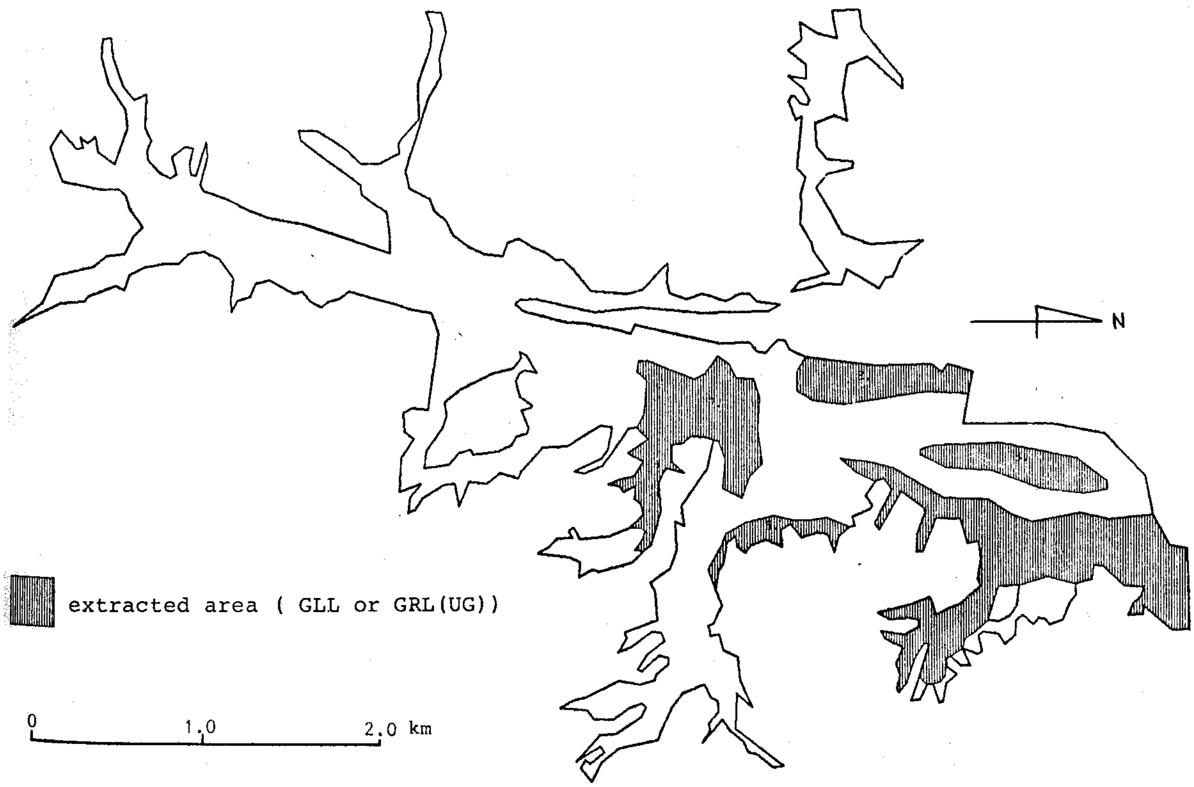


Fig. 3-7 Example of area extraction

thematic maps, provided the interpretation can be derived from the data of the attribute in the Cartographic File. This is the conventional way of compiling an interpretation map on the basis of the soil map. It is well known that this method is simple and useful in many cases where the delineated area is considered homogeneous relative to the attribute. Hence, this program has great importance for rapid data screening and retrieval, and for simple map preparation and publication at the user's request.

Figure 3-7 shows the areas and their identification numbers extracted from the soil map on the requirements of "GLL(Gley lowland soil type)" or "GRL(Gray lowland soil type) and UG(underground gley variety)." Some drainage management may be advised for cultivation of upland crops in the screened area.

3.5 Discussion

The five programs described here enabled two-dimensional retrieval of site data and management and retrieval of polygon data, for which purpose the Cartographic File was provided to COSMAS. It was proved that a two-dimensional display, such as a map or diagram, is very useful in understanding at a glance the distribution pattern and continuous change of data on a given attribute. The polygon data, which is very important information obtained from air-photo interpretation and other sources but which requires much time and labor in its management, became easy to manipulate. The conventional preparation procedure of an interpretation map from the soil map was automated by program "MAP."

The output from these programs are obtainable on a graphic display, an X-Y plotter and printer plotter. Hence, it is advisable that graphic display should be used for determination of the appropriate format for the output by trial and error, while an X-Y plotter and a printer plotter should be used for the final output in a completed format for publication.

Some of the interpretation maps are compiled from the polygon data, while others are done from site data or a combination of the two. When the interpretation can be done with the data stored in the Cartographic File, that is, the required data for the interpretation are considered homogeneous in a given polygon, the interpretation maps are compiled on the basis of polygon delineations through the "MAP" program. When the data in the Cartographic File are, however, not useful in the interpretation, but the site data are, the interpretation map must be compiled from the site data. Program "CONTOUR" was prepared for such situations. An isoline map, however, has limitations in its applicability: it is good for the scaled and multistate-ranked attributes, but not for multistate-unranked attributes. For such a situation, a program "AUTOMAP" can be used for the two-dimensional retrieval of the data of multistate-unranked attribute.

In delineating an area in a map, program "AUTOMAP" employs the probabilities, with which observation sites belong to respective classes assigned by a surveyor or by numerical classification. However, the probability at each site is not the sole base of boundary location. Physiographic change, vegetation discontinuity, etc. must be taken into consideration, but they are too difficult to be shown as an equation, by which a boundary is located, unlike the probability. At present, the author wishes to propose "AUTOMAP" program as the first approximation for a procedure of automatic map compilation based on site information.

Those programs provide us with a consistent procedure of map compilation on the basis of raw site data, thereby attaining high reproducibility in map preparation.

CHAPTER 4 Summary and Conclusion

4.1 Waht has COSMAS done?

A computer-based data management system was set up for collection, storage and retrieval of soil survey data. The method and terminology of soil descriptions were standardized for site and horizon data collection in the field by introducing numerical and letter codes. The description data as well as analytical data are stored and managed in the files of the program package SPSS (Statistical Package for the Social Sciences), which can be used even by those who have no special training or knowledge of computer techniques. SPSS carries out not only data management but also statistical analyses. Data can be screened for users' requirements and the profile description in a conventional text form is generated through the "DECODE" program completed by the author. A large number of raw data which are obtained in soil survey has become accessible to users, employing standard terminology and description.

Cartographic File was provided for the management of polygon data which were derived from various maps prepared in a conventional way. Five programs were provided to COSMAS for the graphic representation of soil survey data. The graphic representation of data as a map or graph is necessary for understanding and interpreting soil survey data and for publishing the results.

Site and polygon data, raw or processed, are automatically turned into a map or a diagram on a graphic display device, X-Y plotter and printer plotter through these programs.

Program "PLOT" transcribes required data onto their observation sites to produce a soil-attribute plotting map. Program "CONTOUR" prepares an isoline map for a given attribute.

Program "TRANSECT" gives a transect-attribute diagram to show the relationship between a given attribute and the topography along a transect set by a user. Program "AUTOMAP" generates a map from site information as regards to a given multistate-unranked soil characteristics. Program "MAP" controls the management and output of polygon data which are stored in the Cartographic File. Whole or screened areas of a thematic map can be reproduced through this program.

Those programs feature interactive query and response on a graphic display device, so that it becomes quick, easy and inexpensive to find the most appropriate map or diagram by trial and error. The final output can be reproduced for publication by means of an X-Y plotter and printer plotter, thereby saving much time and labor.

It is concluded that COSMAS satisfies basic requirements of soil information system with respect to efficient management of raw soil data, easy handling of the system and automated cartography.

4.2 Where is COSMAS going?

COSMAS was provided with basic functions and data for soil information system, but is still under development. The author recognizes the following lines along which COSMAS must be developed in the future;

1. improvement of functions (especially for automated cartography), and
2. cooperation with related information.

In the near future, it may be possible that some functions of COSMAS are modified and improved due to development of peripheral devices and that new functions are provided for COSMAS. Such improvement of functions should be directed towards simple and easy utilization of existing programs and subroutines in the library programs, as well as towards development of new ones. As far as the functional improvement is concerned, it is of great importance that those programs should be compatible with SPSS which carries out basic management of soil survey data in COSMAS. Otherwise, those programs may disturb the efficient operation of COSMAS.

COSMAS is now capable of efficient management and rapid retrieval of soil survey data with a variety of output forms. However, those data alone can hardly be sufficient for the practical requirements of the agricultural management, planning, environmental assessment and so forth. Thus, COSMAS must be able to link its data to those which are made available in related field such as crop management and meteorology. It is another important problem to build up a procedure for linking those data together.

PART II

Practical Use of COSMAS

- Kaya Case Study -

CHAPTER 5 Description of Survey Area

5.1 Location

Kaya Township is located in the northwestern part of Kyoto Prefecture at a distance of 126km from Kyoto City. It occupies about 6000 ha and its population is nearly 10,000 in 1976. Figure 5-1 shows Kaya Township and its surrounding area.

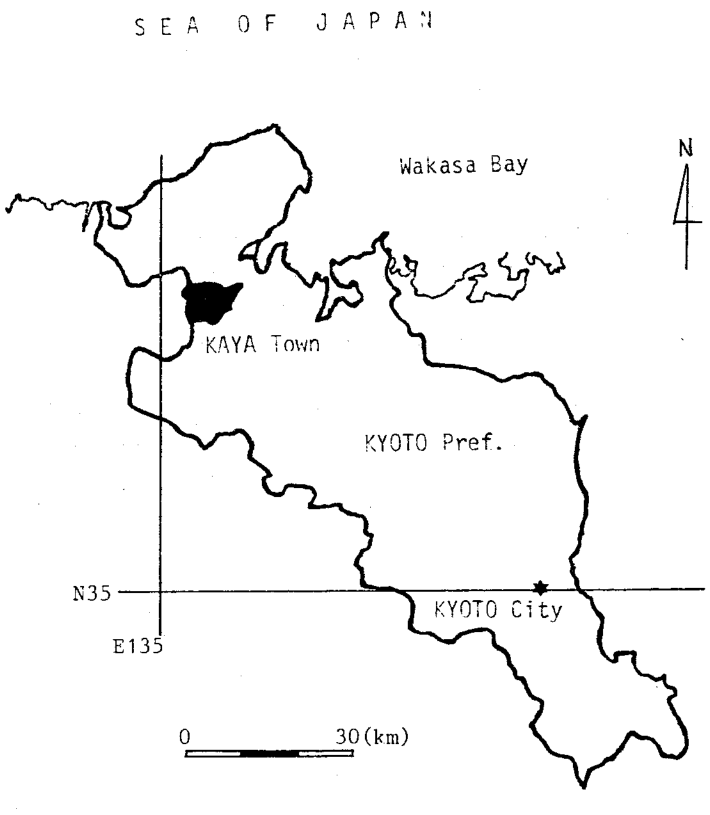


Fig. 5-1 Kaya Township, Kyoto Prefecture, and surrounding area

5.2 Climate

Annual average temperature of the area is 14°C and the highest and the lowest monthly temperatures are 0°C in January and 30°C in August, respectively. Precipitation is about 2,000 mm *per annum* in average with two maxima in winter (due to snow) and in September (due to typhoon).

Table 5-1 shows some climatic data that have been obtained for fifty years at Miyazu Meteorological Station which is adjacent to Kaya Township. Figure 5-2 illustrates the pattern of soil water regime calculated after Kyuma (1973a) using the above data. As can be seen, soil moisture status shows surplus all year round, thus, soil is subject to strong leaching condition.

Table 5-1 Climatic data of the study area

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Temperature (°C)	3.3	3.4	6.1	11.6	16.0	20.5	25.0	26.0	21.9	15.9	10.8	6.0	-
Potential evapo-transpilation (cm)	0.50	0.53	1.56	4.28	7.70	11.13	15.22	15.22	10.46	6.11	3.04	1.25	77.0
Precipitation (cm)	20.90	17.13	14.23	12.32	10.71	16.86	16.05	17.02	23.18	17.05	13.06	20.58	199.09

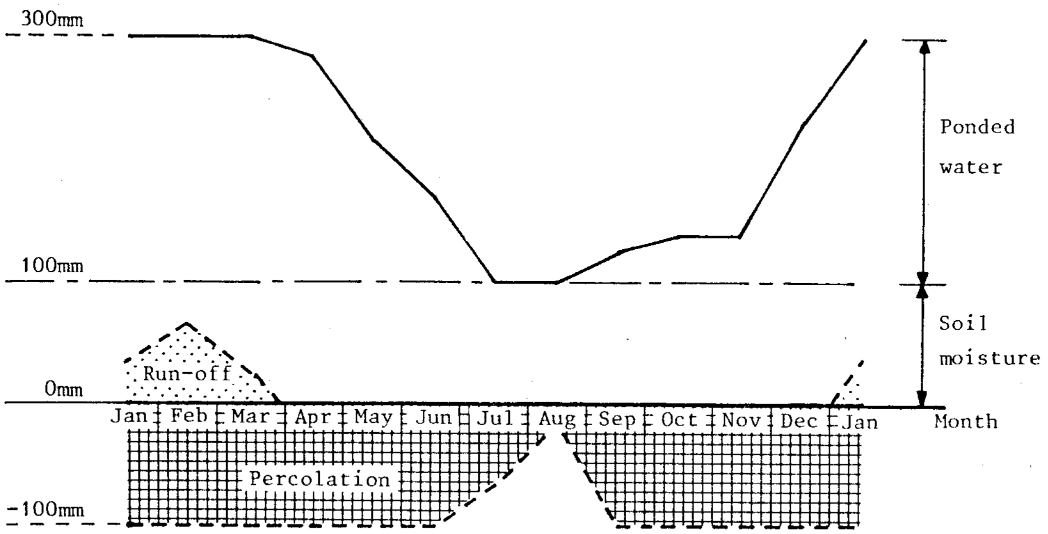


Fig. 5-2 Pattern of soil water regime

5.3 Landuse

Most of the arable land is used for the cultivation of lowland rice in summer and allowed to lie fallow in winter. Upland crops are mainly cultivated in a garden and/or field around houses. Twenty percent of the forest land is managed for production of commercial timbers such as Sugi (Cryptomeria japonica) and Hinoki (Chamaecyparis obtusa), however the management is not intensive. Landuse of Kaya Township is summarized in Table 5-2.

Table 5-2 Landuse of Kaya Township

Lowland paddy	Upland crops	Natural forest	Managed forest	Bamboo forest	Residence	Others	Total
591	87	3515	922	101	69	654	5939

(ha)

5.4 Physiography

The study area consists of a lowland formed by the Noda River and surrounding mountains in the east, south and west. The southern part of the lowland that has a relief class of "rolling" to "hilly" is characterized as a fan, while the northern part is classified as a flood plain or a valley plain. River terraces can be seen on the sides of the lowland. The relief of mountainous area ranges from "hilly" to "steep." The mountains of southeastern part, whose bedrock is serpentine, show smooth and simple slopes and have a few big peaks. On the other hand, the rest of the area, whose bedrock is mainly granite, has relatively complex slopes and consists of many small peaks.

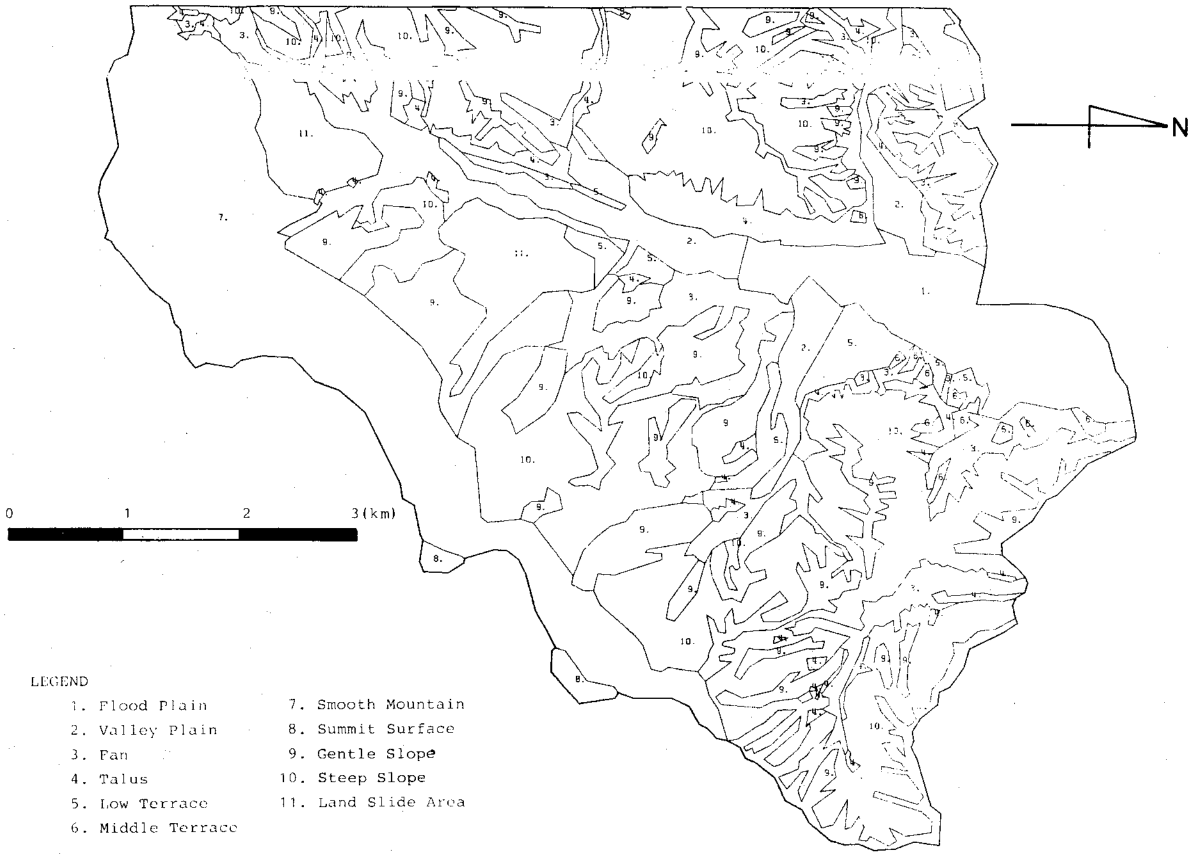


Fig. 5-3 Physiographic map of Kaya Township

The lowest and the highest points in the area are 8 m above sea level in the flood plain of the Noda River and 832 m above sea level on the top of Mt. Oye which is on the southeastern border of the township.

Figure 5-3 shows a physiographic map compiled by an air-photo interpretation. This map is stored as polygon data in Cartographic File of COSMAS with its attributes which characterize delineated areas.

5.5 Geology

Geology of the area is quite simple except the southeastern part. The bedrocks of the mountains in the western and northeastern parts are late mesozoic coarse-grained hornblende biotite granite and biotite granite. In the southeastern part of the area, the picture is more complex and bedrocks such as paleozoic shales and late mesozoic fine-grained granite and serpentine are seen. The lowland consists of recent fluvial deposits that make up valley floors and the lowest terrace. Pleistocene terrace deposits can be seen only in Akeshi and Inanaki area. Figure 5-4 shows geologic map published by Geological Survey of Japan (1965).

5.6 Vegetation

There is a clear difference in vegetation between the serpentine area in the southeast and the rest of the areas dominated by granite. The former is composed of low shrubs of deciduous broadleaved and evergreen tree species and scattered poorly grown red pine trees. Therefore, an openness of the plant cover is a remarkable feature. The vegetation on granite areas has almost

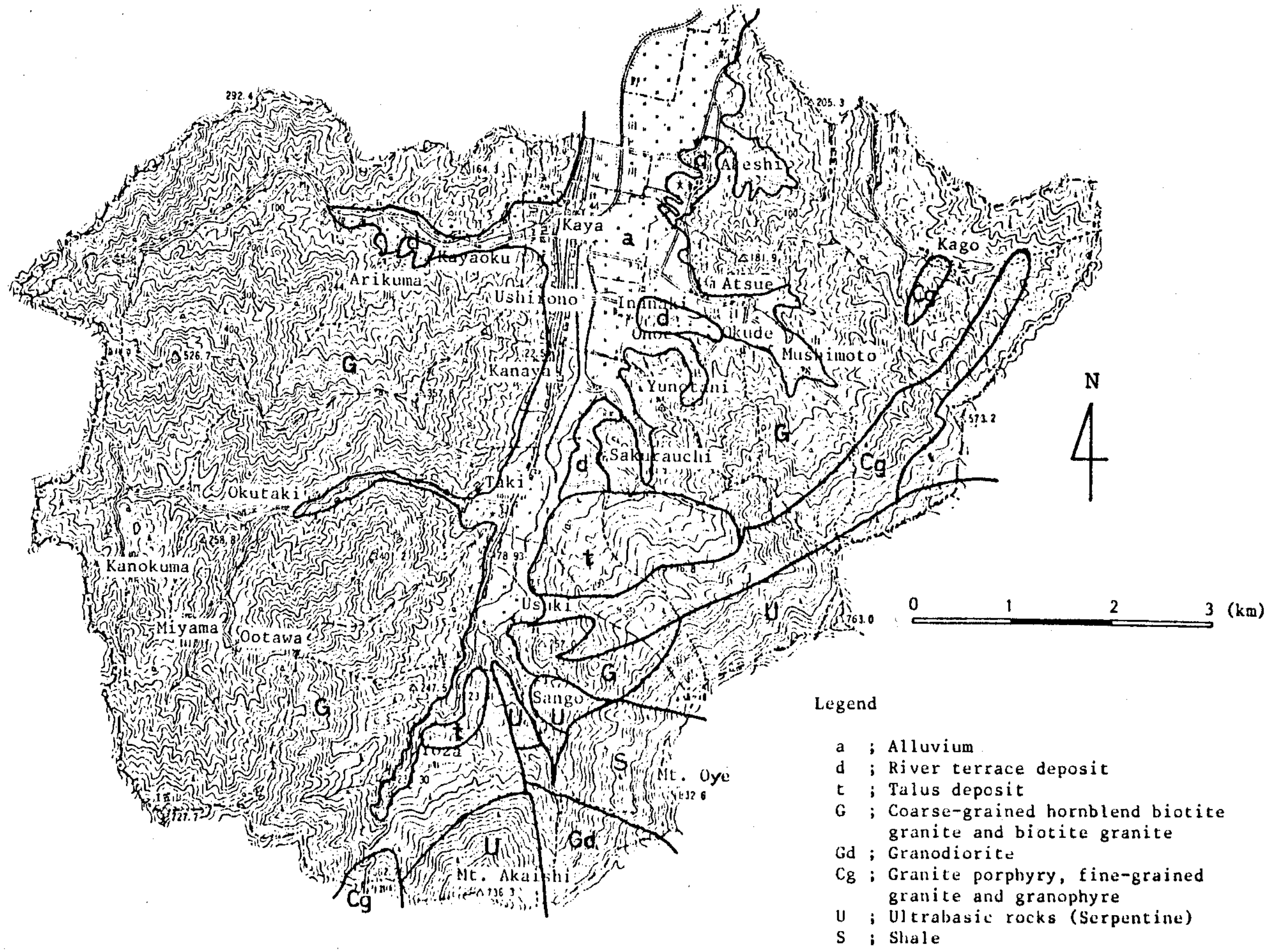


Fig. 5-4 Geologic map of Kaya Township

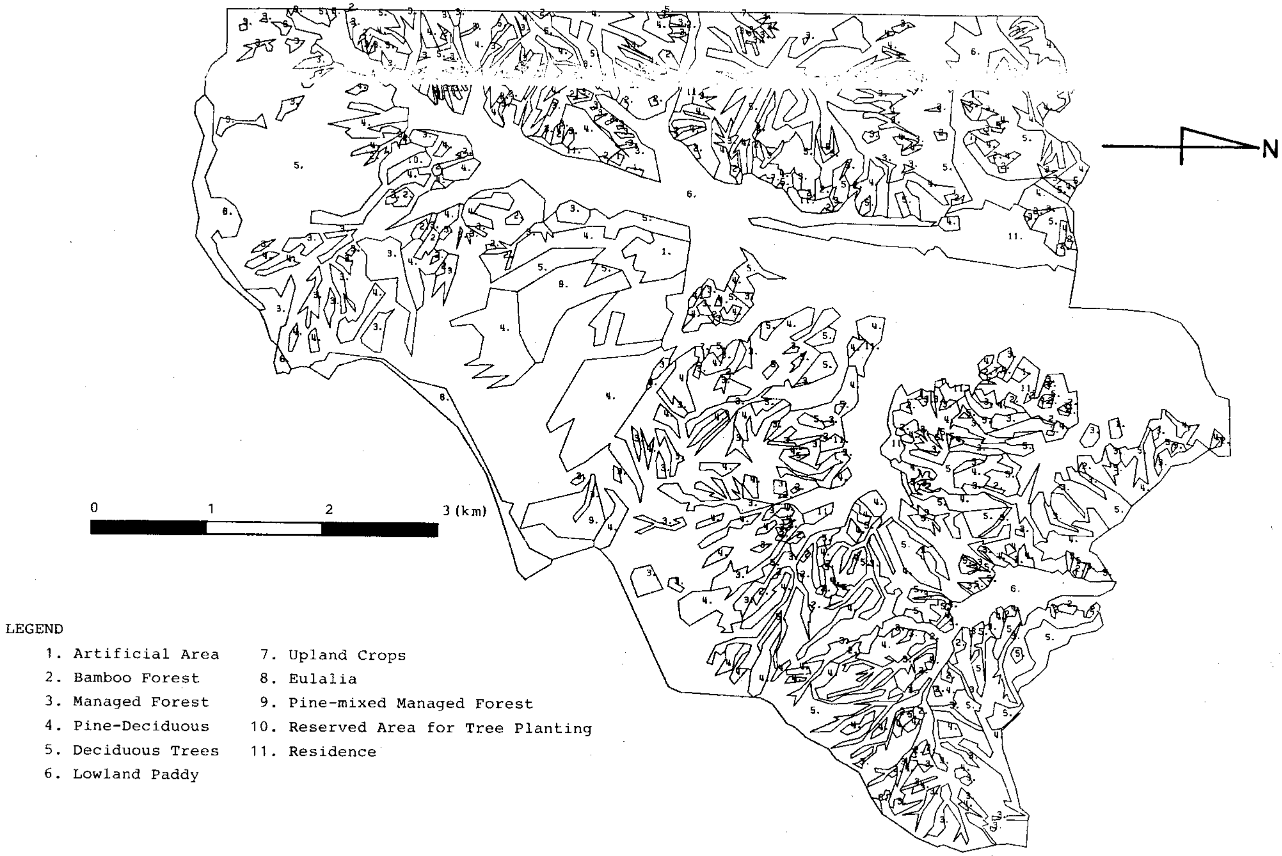


Fig. 5-5 Vegetation map of Kaya Township

the same species composition as the one mentioned above, but all trees are grown much taller and the area is covered with dense canopy.

Tree planting is more intensive and better managed in granite areas than in serpentine area. The summit part of the mountains in the southeast which is higher than 700 m above sea level is covered with bamboo shrubs and Susuki (Miscanthus sinensis). In both the areas, Sugi (Cryptomeria japonica) and Hinoki (Chamaecyparis obtusa) are planted in afforested areas. Natural forest is a mixture of deciduous broadleaved trees such as Quercus crispula, Quercus serrata, Quercus stenophylla and Quercus crenata, and evergreen trees such as Camellia japonica, Eurya japonica, Ilex crenata and Pieris japonica and Pinus desiflora. There can be sporadically seen bamboo forest (Phyllostachys reticulata) on the foot of the mountains. Figure 5-5 shows the vegetation map which was prepared by air-photo interpretation and field observation. All the data of this map are stored in Cartographic File of COSMAS.

CHAPTER 6 Soil Survey

6.1 Profile Observation and Soil Sampling

One hundred and ninety-six profiles and seventy-eight profiles were observed at densities of one per 4 ha in the lowland and one per 9 ha in the mountain area, respectively. Figure 6-1 shows the locations of observation pits where soil samples were taken.

Grid survey (approximately 200 m grid in the lowland and 300 m in the mountain) was carried out so that the sites of soil observation and sampling may not be biased. Site and horizon descriptions were collected on the standardized description card shown in Chapter 2 and transferred into Site Description File and Horizon Description File of COSMAS, respectively, for storage.

6.2 Laboratory Analyses of Soil Samples

Soil samples were analyzed for pH (water and 1N KCl), exchangeable cations (K^+,Na^+, Ca^{2+}, Mg^{2+}), cation exchange capacity, total nitrogen, total phosphorus, phosphorus absorption coefficient, available silica, available phosphorus, free sesquioxides (Fe_2O_3, Al_2O_3, MnO_2), three phase distribution and particle size distribution. From those data the followings were derived; percent base saturation, C/N ratio, bulk density, particle density, water content, pore content and water saturation percentage. Table 6-1 gives a brief description of the methods of laboratory analyses and references. All the data obtained are stored in Analystical Data File of COSMAS.

Table 6-1 Brief description of method of laboratory analysis

pH (water, 1N KCl)	: measured electrometrically in a 1:5 soil/solution mixture of distilled water or 1N KCl solution
Exchangeable cation	: 1N ammonium acetate extraction, measured with atomic absorption for Ca^{2+} and Mg^{2+} and with flame emission for K^{+} and Na^{+} determinations
Cation exchange capacity	: buffered neutral 1N calcium chloride solution medium (pH 8.2) measured with atomic absorption modified from Matsuo (1968)
Total carbon	: Turin's combussion, titrated with Mohr's salt solution (Department of Agricultural Chemistry, Kyoto University, 1973)
Total nitrogen	: digested in Bremner's method (1960), measured with ammonium electrode (Yonebayashi and Hattori, 1980)
Total phosphorus	: digested in Bremner's method, measured colorimetrically (Department of Agricultural Chemistry, Kyoto University, 1973)
Phosphorus absorption coefficient	: neutral 25% diammonium hydrogen phosphate mediumm,measured colorimetrically
Available silica	: acetic acid - sodium acetate buffer extraction (pH4.0), measured colorimetrically (Department of Agricultural Chemistry, Kyoto University, 1973)
Available phosphorus	: 0.2N HCl extraction,measured colorimetrically
Free oxides	: 0.2N oxalic acid extraction under an exposure of sunlight for nearly 5 hours (Matsuo, 1968), measured with atomic absorption for Fe and Mn, and with inductive coupling plasma emission for Al (Fuwa and Haraguchi, 1980) determinations
Three phase distribution	: taken as a soil core sample of 100 cc, actual volume (total volume of solid and liquid phases of the core) were measured, and percentages of three phases were calculated
Particle size distribution	: dispersed in NaOH medium after organic matter removal, followed by pipette method

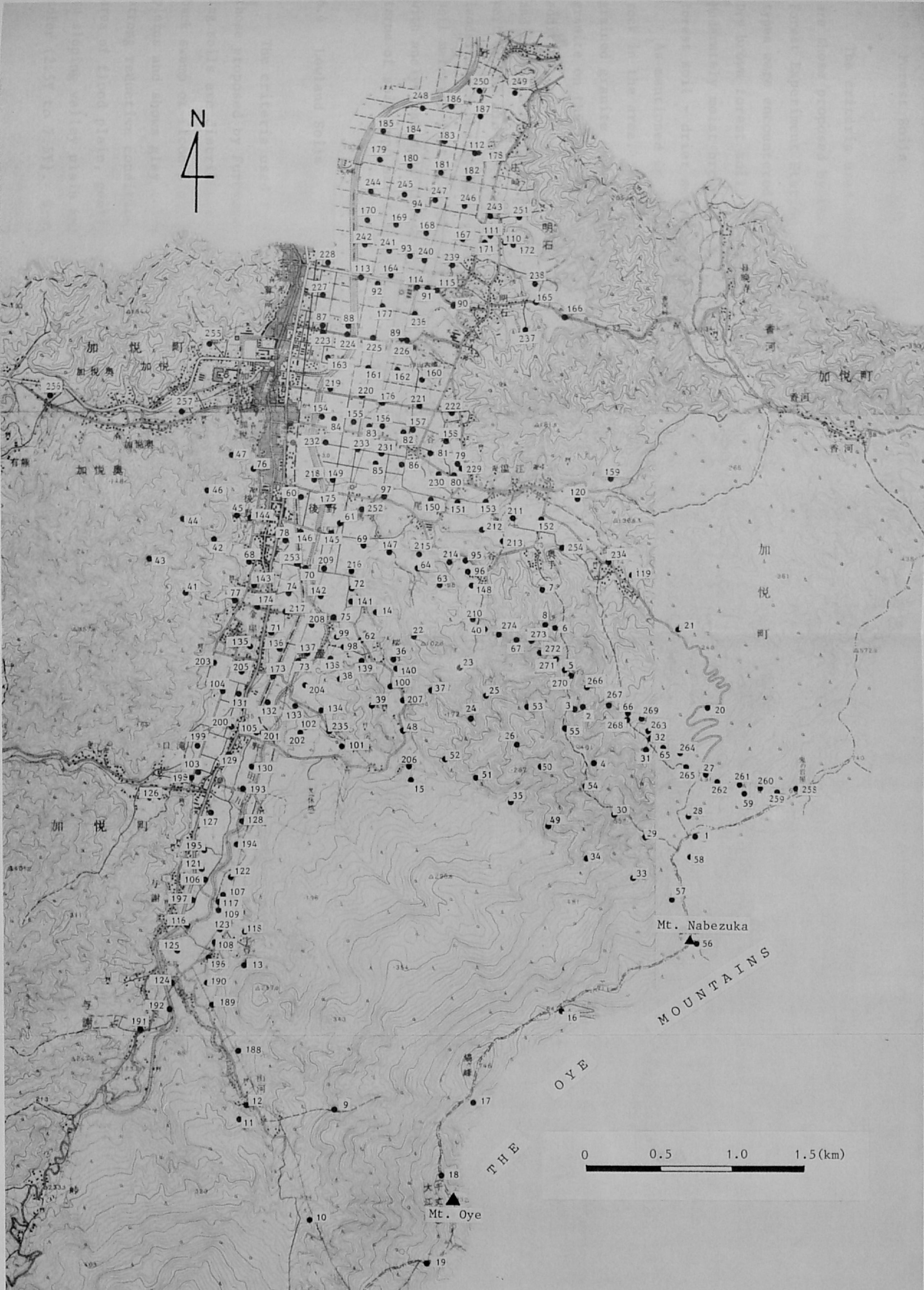


Fig. 6-1 Location map of sampling sites in the study area

6.3 Forest Soils

The criteria used here for the classification of forest soils are those proposed by the Forest Soil Division of Government Forest Experiment Station (1976). Following soil types and subtypes were encountered in the forest part of the study area; Dry brown forest soil - granular and nutty structure type (B_B), Moderately moist brown forest soil (B_D), Moderately moist brown forest soil - drier subtype ($B_{D(d)}$) and Wet brown forest soil (B_F).

As mentioned in 5.5, there can be seen several types of bedrock in the area. They are serpentine on the upper part, fine grained granite on the middle part and coarse-to-medium grained granite on the lower part of the slope in the study area. In addition, one more soil material that is a mixture of serpentine and fine grained granite can be seen in a relatively gently sloping part of the mid-slope position that was previously disturbed by landslides. Hence, there are altogether four different kinds of soil material in the area. The site and horizon descriptions with analytical data for the profiles representative of soil in terms of soil type and soil material are given in Appendix I.

6.4 Lowland Soils

The criteria used for the classification of lowland soil are those proposed by Furukawa (1976). In the study area, the following soils are distributed: Gley lowland soil mainly occurs in the back swamp of flood plain and in the bottom of narrow valley plains and shows gley color throughout the profile because of a strong reductive condition. Gray lowland soil can be seen in the area of flood plain, gently sloping terrace and gently sloping to sloping valley plain and has horizons with dominantly gray color (2.5Y to 7.5Y). Brown lowland soil occupies the area which

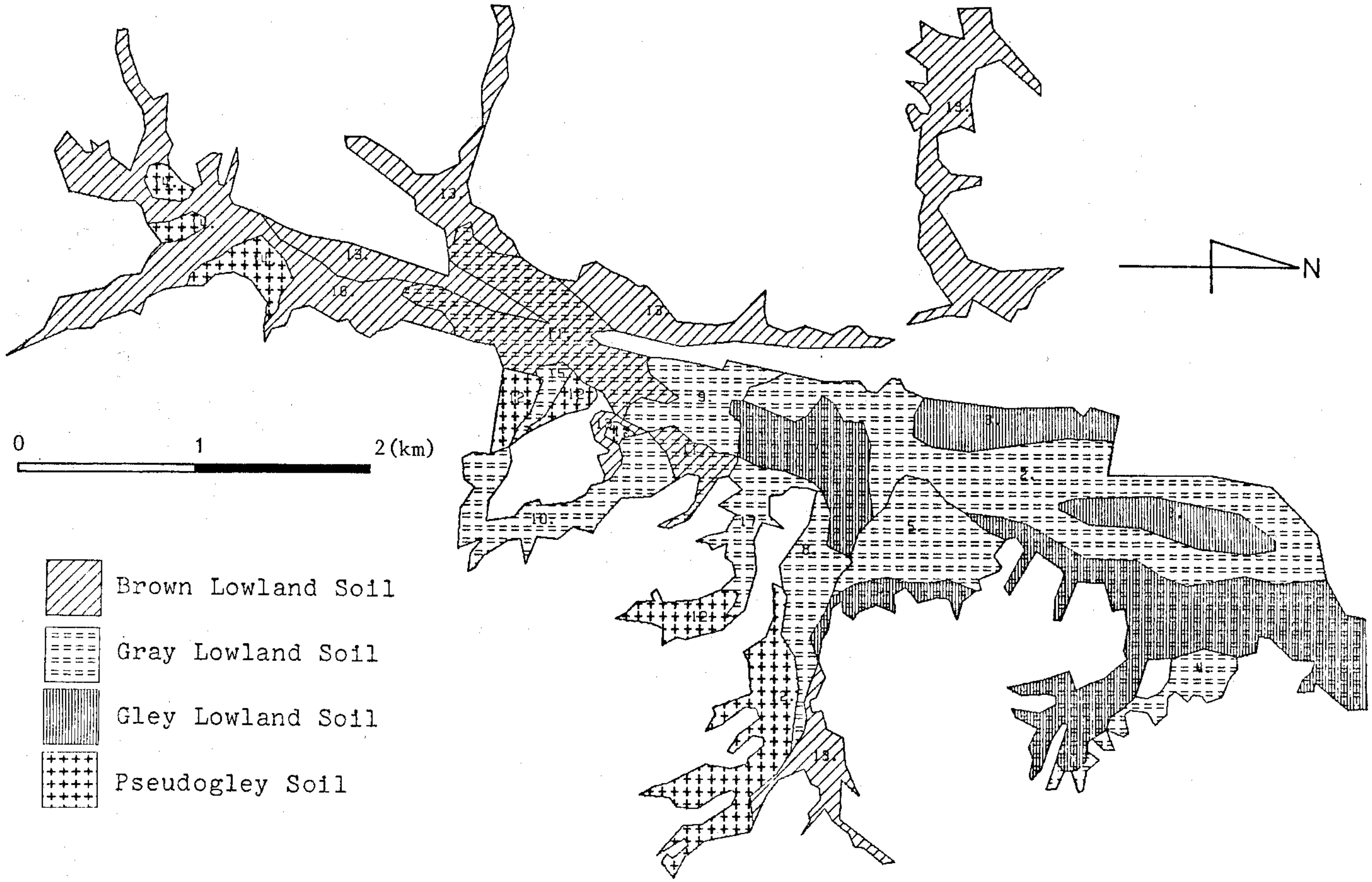


Fig. 6-2 Soil map of lowland of Kaya Township

Table 6-2 Legend of soil map

Mapping Unit No.	Soil Type	Soil Variety	Form		Phase	
			Physiogr. Unit	Soil Texture	Stoniness	Relief
1	GLL	ALL	FP	F		FLAT
1	GRL	UG	FP	M		FLAT
2	GRL	ALL	FP	M		FLAT
3	GLL	ALL	FP	M		FLAT
4	GRL	ALL	FAN	C		G.SL
5	GRL	ALL	TR	F		G.SL
6	GLL	ALL	TR	M		SL
6	GRL	RG	TR	M		SL
7	GLL	ALL	FP	C		FLAT
7	GRL	UG	FP	C		FLAT
8	GRL	ALL	VP	M		SL
9	GRL	ALL	VP	C		G.SL
10	GRL	ALL	VP	M	PM	ROL
11	BLS	ALL	FAN	M		SL
11	GRL	ALL	FAN	M	PM	SL
12	PSG		TR	F		ROL
13	BLS	ALL	FAN	M		ROL
14	PSG		TR	F		SL
15	GRL	ALL	VP	F	CP	SL
16	BLS	ALL	FAN	M	CP	SL
17	GRL	UG	VP	M		G.SL

Abbreviations

Soil Type : GLL(gley lowland soil), GRL(gray lowland soil), BLS(brown lowland soil), PSG(pseudogley soil)

Soil Variety ; ALL(all horizon), UG(underground gley), RG(reverse gley),

Form ; FP(flood plain), FAN(fan), TR(terrace), VP(valley plain), F(fine texture), M(medium texture), C(coarse texture)

Phase ; PM(pebble many), CP(cobble profuse), FLAT(flat), ROL(rolling), G.SL(gently sloping), SL(sloping)

are classified as sloping fan or natural levee of flood plain, shows brown to yellowish-brown color in soil matrix and rarely undergoes reductive condition. Pseudogley soil is mostly observed on a terrace and shows almost always heavy texture which causes poor internal drainage. In such a condition, the soil shows brown to reddish-brown colored mottles in the gray colored matrix because of prolonged water saturation in a certain period of the year.

Figure 6-2 shows the soil map of the study area. Legend is given in Table 6-2. Descriptions with analytical data for the soil profiles representative of the mapping units are given in Appendix II.

CHAPTER 7 Numerical Approach to Soil Material Classification

7.1 Introduction

Soil material has been, heretofore, identified by an experienced surveyor in the field, or by physical and chemical analyses carried out in the laboratory. The surveyor's field judgement is often subjective and uncertain, while detailed laboratory analyses take considerable time and labor, particularly when handling a large number of samples. Field descriptions should be used as efficiently as possible in determining soil material because they are easy to obtain. A numerical classification method may well permit highly reproducible determination of soil material. It works to stated rules. Its advantage is not that the method is objective - someone must initially fix all the procedures and concepts - but that once this is done, the rules can be explicitly stated, and they are uniformly and consistently applied throughout the analysis, as Norris (1970) stated.

This study aims at generation of a procedure for classifying soil material by introducing numerical manipulation of soil data. Since the objective of this study is to classify soil material not only consistently and objectively but also in a manner similar to the conventional way, the most important thing is to find out a rule by which surveyors classify soil material, and formulate it into an appropriate procedure based on statistical methods. Once the procedure is fixed, it determines soil material more objectively and consistently than an experienced surveyor does.

The conventional procedure of a soil surveyor consists of the following steps;

1. he selects soil attributes which distinguish a certain soil material from the others,
2. he sets up soil material classes in the study area, taking

into account the response patterns of the samples to selected soil attributes, and

3. he sets the samples into one of the soil material classes he has chosen.

This chapter describes a numerical procedure to replace these three steps.

For the first step, a surveyor selects, based on his experience, some key attributes out of those obtained in both the field and laboratory. Since the objective of this study is to carry out a reliable classification close to the conventional one, the soil attributes to be used herein should be the same ones which a surveyor employs in his conventional classification.

Next, for setting up the classes various statistical analyses were adopted, as reviewed by Norris (1970) and Arkley (1976). Principal component analysis (Cuanalo and Webster, 1970; Norris, 1971; Kyuma and Kawaguchi, 1973, 1976), factor analysis (Arkley, 1971; Kyuma, 1973b; Suh *et al.*, 1977a,b), and similarity analysis (Hole and Hironaka, 1960; Bidwell and Hole, 1964; Russell and Moore, 1967; Campbell *et al.*, 1970; Cuanalo and Webster, 1970; Moore *et al.*, 1972; Kyuma and Kawaguchi, 1976) were applied to classification of soil groups at different categorical levels and to classification of soil material, and to an evaluation of soil tilth and fertility. These statistical methods are intrinsically applicable only to "scaled attributes," thus, some of the soil attributes employed must be scaled as numerical codes, whereas they are not originally scaled. On the other hand, most of the descriptive data obtained in a soil survey are multistate- ranked or unranked, rather than scaled. Reyner (1966) and Muir *et al.* (1970) assessed similarities among all the horizons of sample profiles by handling separately three kinds of soil attributes: dichotomies, alternatives, and scales. An overall similarity between soil profiles was then obtained on the basis of the average similarity of matched pairs of horizons. Their procedure is much better for simultaneous handling of multi state- ranked and unranked variables.

Hayashi's theory of quantification No. 3 (Hayashi 3) was originally proposed by Hayashi (1956) and applied to the classification of wild rice varieties by Takakura (1962) and to the comparative study of character between the Japanese and the Japanese-Americans by Hayashi (1975). In both examples, all individuals were assigned numerical values, which imply similarities among them based on, what is called, the "response pattern" of qualitative and/or quantitative data for selected variables. This is basically the same procedure that is followed by an experienced surveyor for understanding the relationship between a pair of soil profiles on a given set of soil characters prior to classifying those individuals. The surveyor recognizes the similarity between two individuals on the basis of their response patterns to each of the soil attributes concerned with the classification. Then he sets up several groups of individuals each of which shows a different type of response pattern from the others as soil material class. Therefore, among these statistical procedures, Hayashi 3 is best suited and closest to the conventional procedure.

After the soil material classes have been set up, samples are to be allocated in one of them. It is possible to encounter a sample which cannot be allocated into one of the material classes due to its transitional characteristics between two or more of them. Furthermore, the surveyor's judgement in the field is often variable and hardly comparable to that of another surveyor. In such situations discriminant analysis is helpful, as described by Webster and Burrough (1974) and Norris and Loveday (1971). Discriminant analysis is capable of consistent allocation of a sample into one of the predetermined groups. It is applicable to "scaled attributes." However, no problem arises in handling the multi state- ranked and unranked attributes employed for the classification of soil material, provided the raw data of those attributes are first converted to numerical values.

The author proposes a combination of the two statistical analyses, Hayashi 3 and discriminant analysis, for the numerical procedure which replaces the conventional classification of soil material.

7.2 Study Area and Employed Data

The study area was on the west slope of the mountains in the eastern part of Kaya Township. As shown in Figure 7-1 the area is divided into four regions on the basis of bedrock type: serpentine area, mixed serpentine-granite area, fine grained granite area and coarse-to-medium grained granite area. The fifty-six soil profiles examined in this study were selected so that they would cover the varieties of soil material in the study area. As shown in Figure 7-1, most of the profiles were distributed at intervals of 300 m along four transect lines from the ridge down to the valley, and the rest were between the regular sampling sites to detect more precise differences between soil materials on one of the transects. As shown in previous studies (Webster and Wong, 1969; Webster, 1973; Webster and Cuanalo, 1975) a transect gives, with limited man-power, great deal of information about soils, provided it is laid to include all varieties of soil attributes concerned. It suggests a two-dimensional distribution pattern of a given attribute, given a proper topographic interpretation of the surroundings. By the conventional survey, each sampled profile was classified into one of the soil material classes suggested from the above mentioned bedrock types. Table 7-1 summarizes the results of soil material classification for all sampled profiles.

The soil attributes employed herein for the numerical classification were selected from those which are stored in the COSMAS files, namely Site Description File, Horizon Description File and

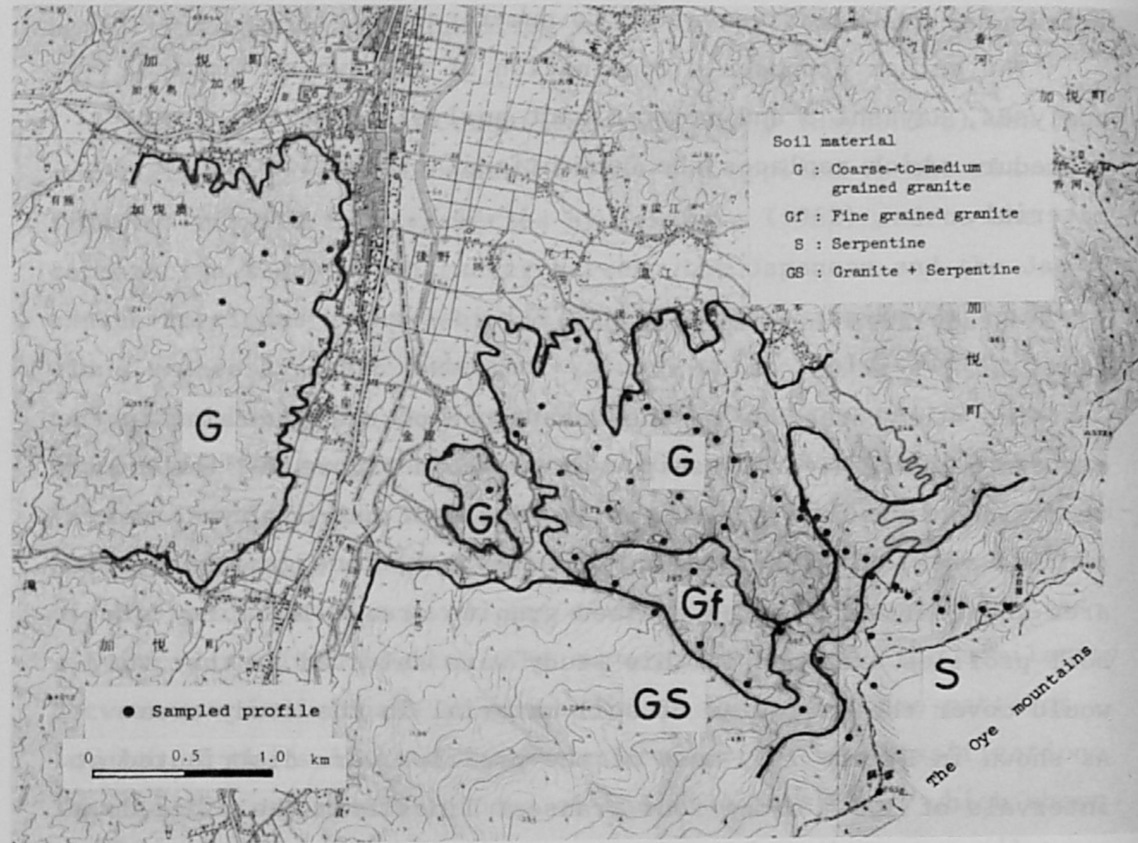


Fig. 7-1 Location of sampled profiles on the west slope of Mt. Oye

Table 7-1 Conventional soil material classification at sampled sites

Type of soil material	Total No. of profiles	Profile numbers
Serpentinic	13	27,28,29,56,57,58,59,258,259,260, 261,262,265
Mixture of serpentine and granite	7	30,33,35,65,263,264,269
Fine-grained granitic	6	34,49,50,51,267,273
Coarse-to-medium grained granitic	23	22,23,24,25,26,31,36,37,38,39,40, 52,53,55,63,66,67,265,268,270,271, 272,274

Analytical Data File. They are the same soil attributes used by a survryor for judging the type of soil material of each profile in the study area. Program "TRANSECT," which was added to COSMAS and described in Chapter 3, was very helpful in understanding the relationship between soil attributes taken as site information, e.g. soil drainage and bedrock type, and the one between site information and its topographical location. The following soil attributes were chosen: soil drainage (DRAIN), texture of subsoil (LTEX), plasticity (LPLAS) and stickiness (LSTIC) of subsoil, size (STSZ) and type (LSTTY) of stones, compactness of surface horizon (UCOMPM) and subsoil (LCOMPM) measured with penetrometer, finger penetrability (COMPF), color (chroma) of subsoil (LCHR), grade of soil structure development (STRG), mode of parent material continuation (PMCONT), exchangeable magnesium content of subsoil (LMG), water content of subsoil (LH2OC), water saturation percentage (LH2O SP), air-phase percentage of subsoil (LAIR) and particle density of subsoil (LPD).

7.3 Soil Material Class Establishment

7.3.1 Hayashi's theory of quantification No. 3 (Hayashi 3)

This is a method of classification of individuals based on the similarity of response pattern with respect to attributes having several attribute-classes. What we call "response pattern" is the pattern of soil attribute-classes to which an individual (i.e. soil sample) belongs, as shown in Figure 7-2 (A).

The check mark (V) indicates that the sample falls into this particular attribute-class of selected soil attribute in question. If the data matrix (A) is rearranged into (B) so that check marks fall along a diagonal in the matrix, those individuals and attribute-classes which are in adjacent positions in the matrix are

(A)

Attribute / Class / Individual	I 1	I 2	I 3	II 1	II 2
1	V				V
2	V				V
3			V		V
4			V		V
5			V	V	
6		V		V	

(B)

Attribute - Class / Individual	I - 1	II - 2	I - 3	II - 1	I - 2
1	V	V			
2	V	V			
3		V	V		
4		V	V		
5			V	V	
6				V	V

Fig. 7-2 Schematic representation of response pattern and Hayashi's theory of quantification No. 3

considered to be similar to each other.

The mathematical objective of Hayashi 3 is to assign numerical values x_j and y_i to the j-th attribute-class and the i-th individual, respectively, so as to maximize the correlation coefficient between x and y. This procedure is equivalent to the rearrangement of matrix as mentioned above, and consequently, both individuals and attribute-classes which have a similar response pattern are given similar numerical values.

When maximizing correlation coefficient ρ between x and y, the ratio of within-variance (σ_W^2) to the total variance (σ^2) for one of the variables, say, x, is to be minimized. It is equal to maximizing correlation ratio, η , which is defined as follows;

$$\eta = \sqrt{1 - \frac{\sigma_W^2}{\sigma^2}} = \sqrt{\frac{\sigma_b^2}{\sigma^2}} \qquad (\sigma^2 = \sigma_b^2 + \sigma_W^2)$$

where, σ_b^2 is the between-variance for x.

A numerical value x is assigned to every attribute-class, when satisfying the above mentioned condition. A numerical value to be assigned to an individual, y, is obtained by summing up numerical values (x's) assigned to attribute-classes to which the individual is checked.

Suppose that the response of the i-th individual to the j-th attribute-class is defined as follows;

$$\delta_i(j) = \begin{cases} 1, & \text{when i belongs to the j-th class} \\ 0, & \text{when it does not} \end{cases}$$

Then between- and total-variances are given as follows;

$$\sigma_b^2 = \frac{1}{T}\sum_i \frac{1}{f_{i.}} \left(\sum_j x_j \ \delta_i(j)\right)^2 - \left(\frac{1}{T}\sum_j x_j \ f_{.j}\right)^2$$

$$\sigma^2 = \frac{1}{T}\sum_j x_j^2 \ f_{.j} - \left(\frac{1}{T}\sum_j x_j \ f_{.j}\right)^2$$

where,

$$f_{.j} = \sum_i \delta_i(j)$$

$$f_{i.} = \sum_j \delta_i(j)$$

$$T = \sum_j f_{.j} = \sum_i f_{i.}$$

To obtain x, which maximizes $\eta^2 = \frac{\sigma_b^2}{\sigma^2}$, one must solve the general eigenvector problem $(\mathbf{H} - \eta^2 \mathbf{F})\ \mathbf{x} = 0$, where the elements of $\mathbf{H}$ and $\mathbf{F}$ are as follows:

$$\mathbf{H}_{jk} = \sum_i \frac{\delta_i(j)\ \delta_i(k)}{f_{i.}} - \frac{f_{.j}\ f_{.k}}{T}$$

$$\mathbf{F}_{jk} = \begin{cases} -\dfrac{f_{.j}\ f_{.k}}{T} & (j \neq k) \\ f_{.j} - \dfrac{f_{.j}\ f_{.k}}{T} & (j=k) \end{cases}$$

The largest eigenvalue ${}^1\eta^2$ and its associated eigenvector ${}^1\mathbf{x}$ define the first dimensional numerical values to the attribute-classes. Likewise, the next largest eigenvalue ${}^2\eta^2$ and its associated eigenvector ${}^2\mathbf{x}$ define the second dimensional ones, whose axis is orthogonal to the former one, and so forth.

The numerical value to be assigned to an individual on the s-th dimensional axis is computed from the linear combination of ${}^s x$'s as follows;

$$s_{y_i} = \frac{1}{f_{i\cdot}} \sum_j s_{x_j} \, \delta_i(j)$$

A detailed mathematical explanation of Hayashi 3 is given by Hayashi (1956, 1975), Yasuda and Unno (1977), and Takakura (1962). All computations are done with one of the subprograms of SPSS, "HAYASI 3" (Miyake and Yamamoto, 1979), which is accessible in COSMAS.

7.3.2 Application and results

Hayashi 3 starts with setting up attribute-classes for each of the selected soil attributes just as a surveyor does when classifying soil materials, and Table 7-2 shows these attribute-classes. Threshold values which define those attribute-classes were assigned so as to distinguish a certain group of soil material from the others. Hayashi 3 was applied to 56 soil profiles by employing their responses to 43 attribute-classes of 17 soil attributes as seen in Table 7-2.

Table 7-3 shows the five largest eigenvalues (η^2), with the cumulative ratio of total variance for each. As shown in the table, the first five eigenvalues explain 62.6 % of the total variance. The solution of Hayashi 3 analysis, i.e. the numerical values to be assigned to each attribute-class, was obtained as an eigenvector corresponding to each of the eigenvalues. Table 7-4 gives five numerical values for each attribute-class derived from the first five eigenvalues.

Assigned numerical values roughly imply the similarities between attribute-classes on the basis of individual's response pattern in the data matrix. To the attribute-classes which were given the five lowest values in the first solution of the analysis (i.e. high water saturation percentage (LH2OSP-III), fragments of serpentine stones (LSTTY-III), high exchangeable magnesium content

Table 7-2 Attribute-class list for soil material classification

Class / *Attribute	I	II	III	unit
DRAIN	v.poor-m.well	well-excess	-	-
LTEX	S,LS,SL,L,SiL, SCL	CL	SiCL,SC,LiC,SiC HC	-
LPLAS	non-weakly	moderately	strongly	-
LSTIC	non-weakly	mod.-strongly	-	-
STSZ	gravel	s.pebble	pebble,cobble boulder	-
LSTTY	granite	granite(fine)	serpentine	-
LCOMPM	<18.0	18.0 - 25.0	25.0 <	mm
UCOMPM	<18.0	18.0 - 25.0	25.0 <	mm
COMPF	2,3,5,	4	-	(code)
LCHR	1 - 5	6 - 8	-	(Munsell)
STRG	3,1	2	-	(code)
PMCONT	0	1	-	(code)
LMG	< 1.0	1.0 - 3.0	3.0 <	me
LH2OC	< 20.0	20.0 - 40.0	40.0 <	%
LH2OSP	< 60.0	60.0 - 80.0	80.0 <	%
LAIR	< 25.0	25.0 - 30.0	30.0 <	%
LPD	< 2.8	2.8<	-	g/ml

* The abbreviations in describing attributes must be referenced in 7.2.

Table 7-3 Eigenvalues, correlation coefficients and cumulative ratios of total variance derived from "Hayashi 3" analysis for soil material classification

	Eigenvalue	Correlation coefficient	Cum. ratio of total variance
1	0.484	0.696	0.313
2	0.186	0.431	0.432
3	0.119	0.345	0.509
4	0.092	0.304	0.569
5	0.088	0.297	0.626

Table 7-4 Numeric values assigned to soil attribute-classes for soil material classification

Attribute	Class	Solution 1	2	3	4	5
DRAIN	I	-1.128	-0.387	-0.206	-0.351	-0.615
	II	1.109	0.317	0.312	0.302	0.511
LTEX	I	1.093	-0.673	0.352	-0.356	-0.077
	II	-0.294	4.606	-1.335	2.419	-1.687
	III	-1.915	-0.958	-0.122	-0.478	0.875
LPLAS	I	1.134	-0.899	0.206	-0.306	-0.046
	II	-0.223	3.110	-0.032	0.885	-1.792
	III	-1.884	-0.763	-0.443	-0.121	1.311
LSTIC	I	1.023	-0.389	0.010	-0.382	-0.343
	II	-1.307	0.459	-0.073	0.482	0.396
STSZ	I	0.627	-0.428	0.568	-0.138	0.633
	II	-0.692	0.727	1.292	2.739	-2.693
	III	-1.062	0.369	-2.979	-2.374	0.861
LSTTY	I	1.009	-0.609	0.420	-0.543	-0.556
	II	0.076	3.373	-1.827	0.772	0.580
	III	-2.039	-1.147	0.334	1.001	0.440
LCOMPM	I	0.670	0.784	0.149	0.541	1.298
	II	-1.285	-0.231	1.121	-1.405	-0.404
	III	0.806	-2.840	-4.055	1.669	-4.567
UCOMPM	I	0.611	0.130	-0.473	0.334	-0.013
	II	-1.320	-0.335	0.942	-0.733	-0.034
COMPF	I	0.505	0.610	-0.286	1.472	0.267
	II	-0.859	-0.415	1.008	-2.217	0.393
LCHR	I	-0.417	0.494	0.403	0.420	1.099
	II	1.071	-1.327	-1.126	-1.086	-2.855
STRG	I	-0.814	0.768	0.182	-0.219	-0.205
	II	1.297	-1.265	-0.358	0.340	0.276
PMCONT	I	0.286	0.274	-0.323	-0.690	0.324
	II	-1.067	-1.109	1.085	2.574	-1.306
LMG	I	0.478	0.412	-0.493	-0.217	0.262
	II	-0.172	0.158	3.259	0.852	-0.951
	III	-1.966	-2.081	-0.874	1.702	-0.441
LH2OC	I	1.536	-1.111	0.660	2.082	4.476
	II	0.463	0.887	0.571	-1.294	-0.798
	III	-1.375	-0.984	-1.258	1.157	-0.682
LH2OSP	I	1.067	-0.045	0.501	0.294	0.156
	II	-1.091	1.732	-2.213	-1.844	0.391
	III	-2.045	-1.512	3.008	1.717	-0.592
LAIR	I	-1.276	0.314	0.063	-0.047	0.000
	II	0.805	0.896	1.364	-1.962	-1.977
	III	1.115	-0.978	-0.971	1.227	1.131
LPD	I	0.284	0.494	1.178	0.209	-0.251
	II	-0.564	-1.038	-2.434	-0.427	0.445

(LMG-III), heavy soil texture (LTEX-III), and strong plasticity (LPLAS-III)) correspond individuals whose soil material is of serpentine origin. On the other hand, the attribute-classes showing the five highest values (i.e. low water content (LH2OC-I), weakly developed structure (STRG-II), weak plasticity (LPLAS-I), high air-phase percentage(LAIR-III) and sandy soil texture (LTEX-I)) are the characteristics of coarse-to-medium grained granitic material. Likewise, the five attribute-classes (i.e. medium soil texture (LTEX-II), fragments of fine-grained granite stones (LSTTY-II), medium plasticity (LPLAS-II), medium water saturation percentage (LH2OSP-II), medium air phase percentage (LAIR-II)), to which higher numerical values were assigned in the second solution of the analysis, indicate the characteristics of fine-grained granitic material. Thus, similar numerical values were given to the attribute-classes showing representative characteristics for each soil material distinguished by a surveyor in the field.

Next, the scores to be assigned to an individual were computed from a linear combination of these values with respect to each solution, taking the response of the individual to each attribute-class into consideration. Thus, those were also given in five dimensions as shown in Table 7-5. These numerical scores imply similarity between individuals.

In order to set up the soil material class each profile was plotted in two dimensional space, taking the first two scores assigned to the individual as coordinates, as shown in Figure 7-3. The first two eigenvalues explain 43.2 % of the total variance as shown in Table 7-3 and further eigenvalues contribute much less than the first two eigenvalues. Thus, it is best to use only the first two scores in representing the samples in a scattergram. Each of the samples was plotted with a label of the soil material group assigned in the field by the surveyor. An ellipse shows a statistical boundary within which 90 % of the population are

Table 7-5 Numeric values assigned to profiles for soil material classification

Profile No.	Soil material* (field judgement)	Numeric values 1	.2	3	4	5
22	1.	0.7663	-0.0592	·0.2359	0.0824	0.3552
23	1.	0.5548	-0.1104	0.1475	-0.1549	-0.0744
24	1.	0.6419	-0.6869	-0.6534	0.0590	-0.3724
25	1.	0.3642	-0.0075	0.2321	0.2393	0.1088
26	1.	0.7104	-0.1091	0.2169	-0.4218	-0.1820
27	4.	-1.0976	-0.2456	0.4719	0.2654	-0.1180
28	4.	-1.1618	-0.3109	0.3667	0.1862	-0.0634
29	4.	-1.1612	-0.3320	0.3733	0.5952	-0.1668
30	5.	-0.3428	0.6383	0.3890	0.6239	-0.3879
31	1.	0.3800	-0.5142	-0.3644	-0.0625	-0.7353
33	5.	-0.0878	0.7934	-0.4613	0.3742	0.0701
34	2.	-0.2876	1.0335	0.1116	-0.1384	-0.3424
35	5.	-0.1544	0.8022	-0.1568	0.4353	-0.1923
36	1.	0.4434	-0.1406	0.0725	-0.2029	-0.2012
37	1.	-0.0488	0.1782	0.2391	-0.4938	-0.3761
38	1.	0.4378	0.2220	0.1939	·0.3006	0.0047
39	1.	0.7845	-0.1695	0.0986	0.2700	0.5381
40	1.	0.4602	0.1175	0.1203	0.0894	0.2430
41	1.	0.7845	-0.1695	0.0986	0.2700	0.5381
42	1.	0.5000	0.1145	-0.0835	-0.0930	0.2130
43	1.	0.7296	0.0647	-0.0336	0.3473	0.6049
44	1.	0.4992	0.4137	0.2484	-0.0791	-0.0823
45	1.	0.6783	-0.3642	0.1681	-0.0984	0.3099
46	1.	0.3358	-0.8997	-0.7014	0.1433	-0.4944
47	1.	0.4330	-0.0642	0.5265	-0.6065	-0.3818
49	2.	0.1280	0.7305	-0.0120	0.1532	0.1121
50	2.	-0.0905	1.0552	-0.1964	0.2792	-0.2420
51	2.	-0.1386	1.0189	-0.1669	0.0848	-0.0367
52	1.	0.6660	-0.2448	0.3954	0.0156	0.4742
53	1.	0.6649	0.0434	0.4514	-0.1536	-0.0264
55	1.	0.7373	-0.4537	-0.1610	0.2412	-0.4474
56	4.	-0.9866	-0.1510	0.3482	0.0762	-0.0467
57	4.	-1.1763	-0.4227	0.1799	0.4553	-0.0122
58	4.	-1.2138	-0.5504	0.1944	0.1716	0.0773
59	4.	-0.9781	-0.2652	0.5739	0.2758	-0.0012
63	1.	0.0652	0.2171	0.1971	-0.4534	-0.0173
65	5.	-0.1679	0.7410	-0.7545	-0.0277	-0.1544
66	1.	0.8025	-0.4219	-0.1960	0.4170	-0.2369
67	1.	0.6895	-0.3945	-0.4137	0.1810	-0.5062
258	4.	-0.8660	-0.1380	-0.0503	-0.3462	0.2224
259	4.	-0.9003	-0.1855	-0.1736	-0.0879	0.1776
260	4.	-1.0698	-0.0995	-0.1610	-0.5116	0.2144
261	4.	-0.6544	-0.2997	-0.1987	-0.1026	0.3369
262	4.	-1.2549	-0.3126	-0.2213	-0.1694	0.1485
263	5.	-1.0951	-0.1709	-0.4803	-0.1444	0.2370
264	5.	-0.5704	0.3785	-0.5417	-0.4546	0.3886
265	4.	-0.8585	-0.2971	-0.8680	0.0992	-0.0067
266	1.	0.7590	-0.2492	-0.2090	-0.0546	0.0344
267	2.	0.6166	0.0922	-0.2513	0.1113	0.3356
268	1.	-0.2027	0.1063	0.0143	-0.7263	0.0000
269	5.	-0.6785	0.2580	-0.1471	-0.5582	0.3317
270	1.	0.6145	-0.1903	-0.0916	-0.2906	-0.2147
271	1.	0.5790	0.1779	0.2625	-0.1491	0.0167
272	1.	-0.2774	-0.0784	0.7934	-0.2535	-0.3382
273	2.	0.2320	0.2336	0.1612	-0.0158	-0.2088
274	1.	0.7346	-0.2596	-0.1139	0.2325	0.5791

* Soil material

1 : Coarse-to-medium grained granitic material
2 : Fine grained granitic material
4 : Serpentinic material
5 : Mixed material (granite and serpentine)

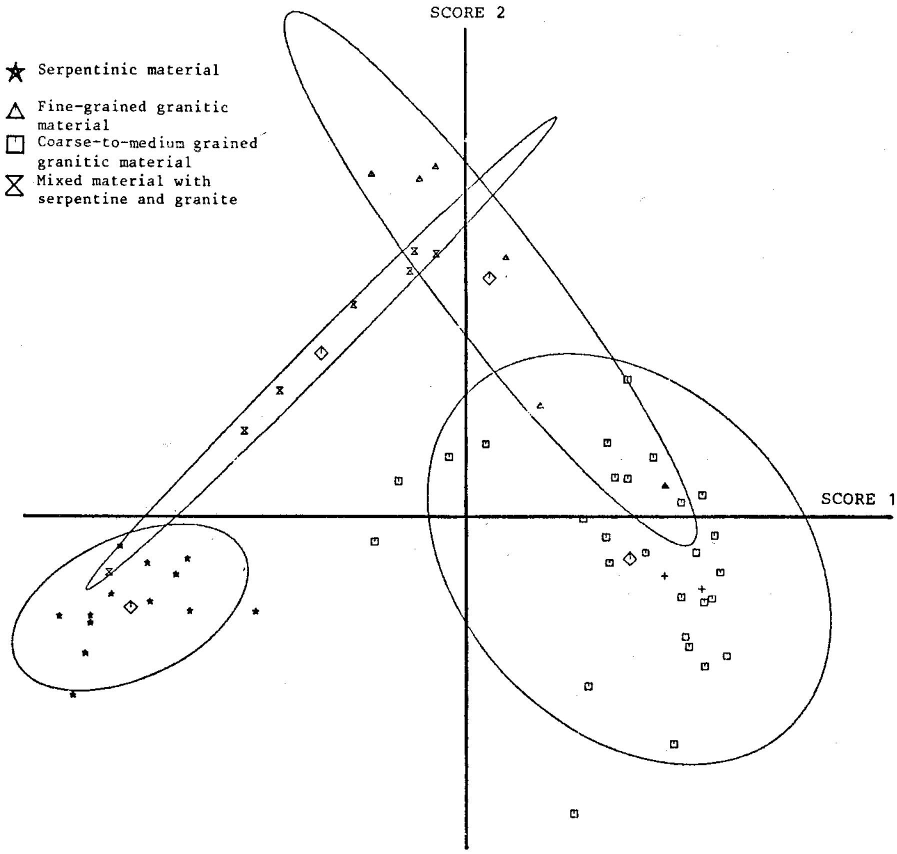


Fig. 7-3 Scattergram of sampled sites plotted with the first two numeric scores assigned by "Hayashi 3" for soil material class establishment

expected to fall (Okuno et al., 1972). This was drawn using the mean, standard deviation and variance of the scores which were assigned to the profiles classified into one group by a conventional method as shown in Table 7-6.

The 90 % probability ellipses occupy different positions from each other except for small areas of overlaps. Thus, profiles with the same label cluster together and are fairly clearly differentiated from each other in the two dimensional space created by the scores, which are the first two solutions in Hayashi 3.

Table 7-6 Statistics for each soil material group

Soil material* group	Statistics	Solution 1	2	3	4	5
1	mean	0.506	-0.129	0.061	-0.038	-0.016
	variance	0.083	0.083	0.104	0.085	.130
	s.d.	0.288	0.289	0.323	0.291	0.360
2	mean	0.077	0.719	-0.059	0.079	-0.064
	variance	0.088	0.141	0.025	0.017	0.054
	s.d.	0.296	0.376	0.157	0.131	0.232
4	mean	-1.029	-0.278	0.057	0.070	0.058
	variance	0.028	0.014	0.148	0.089	0.021
	s.d.	0.168	0.117	0.385	0.298	0.145
5	mean	-0.442	0.491	-0.308	0.035	0.042
	variance	0.113	0.111	0.120	0.179	0.074
	s.d.	0.336	0.333	0.347	0.423	0.273

* Soil material group

1 : Coarse-to-medium grained granitic material
2 : Fine grained granitic material
4 : Serpentinic material
5 : Mixed material (granite and serpentine)

Three- and higher-dimensional ordination of samples is expected to better differentiate these probability ellipses. This means that the numerical methods adopted herein reproduce more objectively the soil material class establishment done in the field by a surveyor. Consequently, in the study area four soil materials i.e. serpentinic material, mixed material of granite and serpentine, fine-grained granitic material and coarse-to-medium grained granitic material, were not only conventionally but numerically established by means of Hayashi 3.

7.4 Sample Allocation

7.4.1 Discriminant analysis

Discriminant analysis begins with the desire to statistically distinguish between two or more groups of individuals. These "groups" are defined by the particular research situation. To distinguish between the groups, the researcher selects a collection of discriminating variables that measure characteristics by which the groups may be best discriminated. The mathematical objective of discriminant analysis is to weight and linearly combine those discriminating variables in a certain fashion so that the groups may be numerically discriminated.

A discriminant function, a linear combination of the discriminating variables, takes the following form,

$$^{s}y_i = v_{s1}x_{1i} + v_{s2}x_{2i} + \cdots\cdots\cdots + v_{sp}x_{pi}$$

where, $^{s}y_i$ is the score of the s-th discriminant function of the i-th individual, the v_s's are weighting coefficients, or discriminant coefficients, and x_{pi} is the value of the p-th discriminating variable used in the analysis. The maximum number of functions which can be derived is either one less than the number of groups (g-1) or equal to the number of discriminating variables (p), if there are more groups than variables. Each function is orthogonal to the others.

Discriminant coefficients are computed so as to maximize the ratio of the between-group variance to the within-group variance. In general terms, it requires solving the general eigenvector problem $(\mathbf{B} - \lambda\mathbf{W})\mathbf{v} = 0$, where $\mathbf{B}$ and $\mathbf{W}$ are, respectively, the between- and within-groups variance-covariance matrices. The largest eigenvalue $^{1}\lambda$ and its associated eigenvector $^{1}\mathbf{v}$ define the first discriminant function (^{1}y). Likewise, further discriminant functions, ^{s}y (s=2,3,.....,g-1) are derived by using the next largest eigenvalues, $^{s}\lambda$ (s=2,3,.....,g-1) when "g-1" is less than "p." Consequently, each individual is defined with those discriminant scores at most in (g-1) dimensional space.

Once the discriminant functions have been derived, they can be used not only in allocating an unknown individual into one of the predetermined groups, but also in testing the adequacy of a classified individual. Under the assumption of a multivariate normal distribution for each of the groups, the discriminant scores can be converted into probabilities of group membership, which are to be used for allocating the individuals into appropriate groups.

The probability density (P_{ji}) of the i-th individual with respect to the j-th group can be computed from the generalized distance between the individual (i) and the centroid (m_j) of the j-th group. The density function for the normal distribution is as follows:

$$P_{ji} = \frac{1}{\sigma\sqrt{2\pi}} \exp\left(-\frac{1}{2}\chi^2_{ji}\right)$$

where, σ is the standard deviation computed from discriminant scores y_i's, and $\chi^2{}_{ji}$ is the generalized distance between the individual and the centroid, defined as follows:

$$\chi^2{}_{ji} = \frac{(y_i - m_j)^2}{\sigma^2}$$

Likewise, the probability densities with respect to other established groups are also calculated. The relative probability of membership in each group is obtained from those probability densities. In addition, a priori knowledge of group probabilities are also taken into account, when available.

Therefore, the relative probability of k-th group membership for the s-th individual, $P(G_k/y_s)$, is given as follows;

$$P(G_k/y_s) = q_k P_{ks} / \sum_j q_j P_{js}$$

where, q_j is an a priori probability of j-th group. When no a priori knowledge of group probability is available, 1/g is equally assigned for each group as the a priori probability. Finally, an individual is allocated into the group, for which the individual has the highest probability of membership.

The above mentioned procedures for deriving discriminant functions and allocating an individual are detailed in several multivariate statistics texts, such as Moriya and Iguchi (1976), and Cooley and Lohnes (1971). All the computations in discriminant analysis were done with one of the subprograms of SPSS, "DISCRIMINANT" (Nie et al., 1975).

7.4.2 Application and results

In order to allocate individual profiles into one of the predefined soil material classes, discriminant analysis was performed using the results of the quantification of each individual carried out in 7.3. The samples which were included within the 90 % probability ellipses computed for the respective soil material classes in 7.3 using the scores of the samples, were used to derive the discriminant functions. The five dimensional numerical scores, which were obtained for each individual by the linear combination of five dimensional numerical values assigned to each soil attribute-class taking the response pattern of the individual into consideration, were employed as discriminating variables in the analysis.

Consequently, fifty out of fifty-six profiles were used and tested for the adequacy of their surveyor's class allocation and the rest were set into appropriate classes using the derived discriminant functions. As shown in Table 7-7, prior probability was given by the relative size of each soil material class: that

Table 7-7 Prior probabilities for respective soil material groups

	Coarse-to-medium grained granitic material	Fine grained granitic material	Mixed material (granite + serpentine)	Serpentinic material
No. of samples	30	6	7	13
Prior probability	0.536	0.107	0.125	0.232

is, the ratio of the number of individuals which fell within the 90 % probability ellipse for the class to the total number of individuals used in the analysis.

Three discriminant functions were derived from three eigenvalues, as shown in Table 7-8. A sample profile was assigned

Table 7-8 Eigenvalues and relative percentages for derived discriminant functions for soil material classification

Discriminant function	Eigenvalue	Relative percentage
1	11.638	83.2
2	2.294	16.4
3	0.058	0.4

three discriminant scores by these derived discriminant functions. Table 7-9 shows discriminant scores, probabilities of membership in each soil material group and the group assignment for each of the samples. As shown in Table 7-8 the first two discriminant functions accounted for 99.6 % of the variation between groups. Thus, the results of the analysis can be represented in the two-dimensional space created with these two discriminant functions, leaving out the third discriminant function. As shown in Figure 7-4, the samples were plotted on the scattergram by the discriminant scores computed from the first two discriminant functions as the coordinates. In the scattergram, the statistically computed territorial boundaries are also shown. The sample which fell within these boundaries were judged members of the respective soil material classes. The samples were plotted on the scattergram with the label of soil material class assigned by the surveyor in the field.

Table 7-9 Numerical assignment of soil material group for sample profiles

Profile No.	Soil material group *		Probability of membership *				Discriminant scores		
	Field judgement	Numerical assignment	1	2	4	5	1	2	3
22	1	1	1.000	0.000	0.0	0.0	3.3847	-0.7375	-0.1140
23	1	1	1.000	0.000	0.0	0.0	3.0542	-0.8310	-0.1794
24	1	1	1.000	0.000	0.0	0.0	2.5985	-1.4897	1.8336
25	1	1	0.997	0.003	0.0	0.000	1.4118	-0.5027	-0.5608
26	1	1	1.000	0.000	0.0	0.0	4.3969	-1.0073	-0.2759
27	4	4	0.0	0.0	1.000	0.000	-5.3426	-1.9257	-1.4331
28	4	4	0.0	0.0	1.000	0.000	-5.6641	-2.0233	-1.0115
29	4	4	0.0	0.0	1.000	0.000	-6.2586	-1.9744	-1.4002
30	5	5	0.000	0.255	0.000	0.745	-1.9092	1.7457	-2.3115
31	1	1	1.000	0.000	0.0	0.0	2.1251	-1.3781	0.6282
33	5	5	0.000	0.316	0.0	0.684	-1.2724	3.7142	0.4417
34	2	2	0.000	0.941	0.0	0.059	-0.5112	3.4706	-1.3220
35	5	2	0.000	0.524	0.0	0.476	-1.2324	3.2532	-0.6755
36	1	1	1.000	0.000	0.0	0.0	2.6428	-0.3278	-0.0829
37	1	1	0.974	0.026	0.0	0.000	1.1297	-0.0465	-0.7923
38	1	1	0.970	0.030	0.0	0.000	1.7851	0.4609	-0.7760
39	1	1	1.000	0.000	0.0	0.0	2.8645	-0.8670	0.3908
40	1	1	0.995	0.005	0.0	0.000	1.9568	0.1102	-0.1090
41	1	1	1.000	0.000	0.0	0.0	2.8645	-0.8670	0.3908
42	1	1	0.996	0.004	0.0	0.000	2.3220	0.4033	0.5093
43	1	1	0.998	0.002	0.0	0.000	2.2746	0.2554	0.5714
44	1	1	0.986	0.014	0.0	0.000	2.8854	0.9778	-0.8864
45	1	1	1.000	0.000	0.0	0.0	3.1694	-1.8248	0.3448
46	1	1	1.000	0.000	0.0	0.000	0.9962	-2.1969	1.8877
47	1	1	1.000	0.000	0.0	0.0	3.7959	-1.4462	-1.2240
49	2	2	0.001	0.987	0.0	0.013	0.4421	2.2282	-0.4781
50	2	2	0.000	0.917	0.0	0.083	-0.5827	4.2325	-0.7000
51	2	2	0.000	0.859	0.0	0.141	-0.6518	3.9591	-0.4020
52	1	1	1.000	0.000	0.0	0.0	2.9852	-1.7537	-0.2247
53	1	1	1.000	0.000	0.0	0.0	3.8157	-0.7783	-1.0049
55	1	1	1.000	0.000	0.0	0.0	3.2583	-1.4019	0.2120
56	4	4	0.0	0.0	1.000	0.000	-4.6226	-1.4111	-0.9684
57	4	4	0.0	0.0	1.000	0.0	-6.3981	-2.0365	-0.5864
58	4	4	0.0	0.0	1.000	0.0	-6.2076	-2.6433	-0.2404
59	4	4	0.0	0.0	1.000	0.000	-4.8136	-2.1844	-1.5442
63	1	1	0.971	0.029	0.0	0.000	1.2795	0.1634	-0.3402
65	5	5	0.000	0.328	0.0	0.672	-1.0300	3.9149	1.2486
66	1	1	1.000	0.000	0.0	0.0	3.0767	-1.1791	0.3947
67	1	1	1.000	0.000	0.0	0.0	3.0009	-0.7572	0.7863
258	4	4	0.0	0.000	0.992	0.008	-3.8699	-0.8143	0.6302
259	4	4	0.0	0.0	0.998	0.002	-4.5374	-0.6942	0.7537
260	4	4	0.0	0.0	0.997	0.003	-4.6401	-0.5481	0.9640
261	4	4	0.0	0.000	0.988	0.012	-3.5182	-1.0744	1.1119
262	4	4	0.0	0.0	1.000	0.000	-6.2282	-0.9703	1.2064
263	5	4	0.0	0.0	0.999	0.001	-5.6624	-0.1464	1.6067
264	5	5	0.0	0.001	0.000	0.999	-2.6501	1.9591	1.7963
265	4	4	0.0	0.0	0.980	0.020	-5.0572	0.1799	2.2906
266	1	1	1.000	0.000	0.0	0.0	3.4618	-0.6879	0.9074
267	2	1	0.992	0.008	0.0	0.000	2.2988	0.6773	0.9630
268	1	1	0.883	0.098	0.000	0.018	0.2634	-0.0473	0.3798
269	5	5	0.000	0.002	0.013	0.985	-2.6749	0.7806	0.8712
270	1	1	1.000	0.000	0.0	0.0	3.4698	-0.6973	0.4232
271	1	1	1.000	0.000	0.0	0.0	3.2487	0.0452	-0.5865
272	1	1	0.998	0.002	0.000	0.000	-0.0469	-1.9256	-2.1696
273	2	1	0.831	0.169	0.0	0.000	1.5154	0.8357	-0.8152
274	1	1	1.000	0.000	0.0	0.0	2.4640	-0.8546	1.0636

* Soil material group

1 : Coarse-to-medium grained granitic material
2 : Fine grained granitic material
4 : Serpentinic material
5 : Mixed material (granite and serpentine)

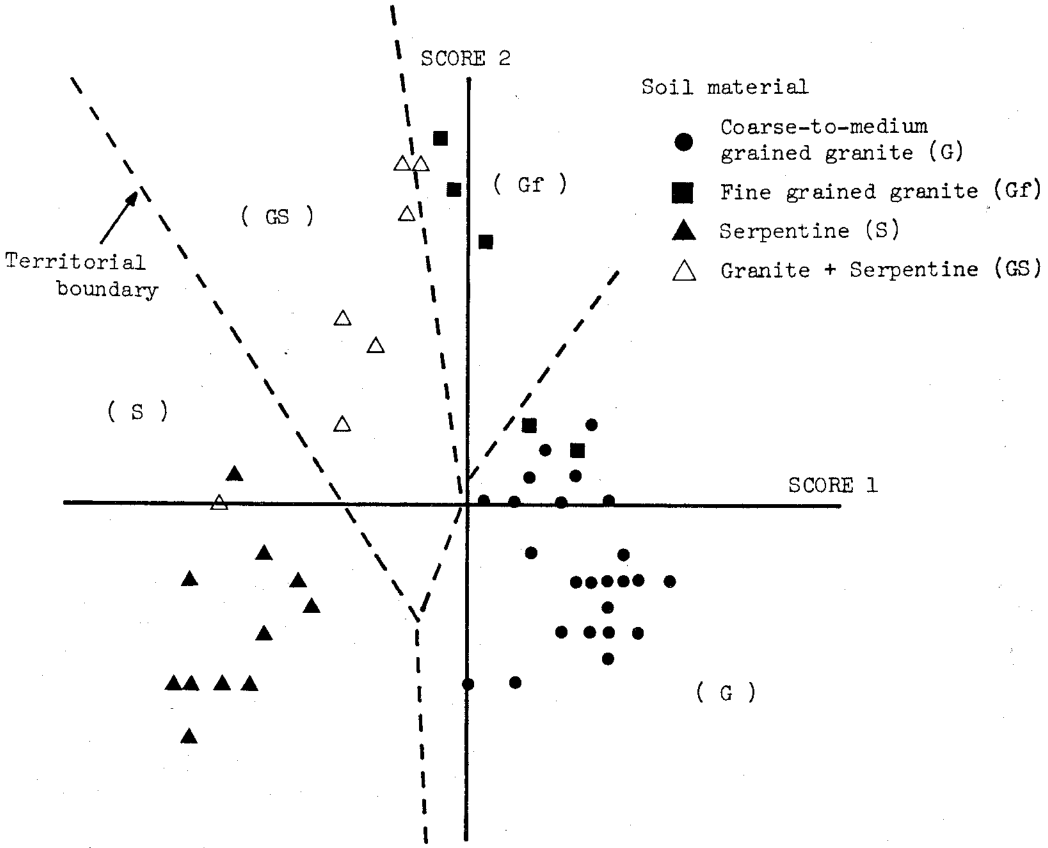


Fig. 7-4 Scattergram of sampled sites plotted with the first two discriminant scores for classifying soil material

Three groups, labeled serpentinic, fine grained granitic, and coarse-to-medium grained granitic materials, are compactly clustered and separate from each other. Samples with mixed material of serpentine and granite are somewhat dispersed but occupy an area between the two end-member groups. It is reasonable that samples of mixed material show such a distribution pattern in the scattergram, considering their characteristics and geographical location in the study area.

7.5 Discussion and Conclusion

The results of numerical classification of the soil samples into appropriate soil material classes are compared with the surveyor's field observation in Table 7-10. Fifty-two out of fifty-six profiles (92.9 %) were numerically allocated into the same classes as those assigned by the surveyor. All samples belonging to the two end-members of soil material, coarse-to-medium grained granitic material and serpentinic material, were correctly classified. However, some profiles belonging to the other two classes

Table 7-10 Cross-table between field judgement and numerical assignment on soil material classification of sample profiles

Field judgement	No. of individuals	Numerical assignment G	Gf	S	GS
G	30	30	0	0	0
Gf	6	2	4	0	0
S	13	0	0	13	0
GS	7	0	1	1	5

Percent of "grouped" individuals correctly classified : 92.9 %

G : Coarse-to-medium grained granitic material
Gf : Fine grained granitic material
S : Serpentinic material
GS : Mixed material (granite + serpentine)

were misclassified. Some soil characteristics are common to both fine grained granitic and coarse-to-medium grained granitic materials. Hence, it is quite difficult to distinguish one from the other by those soil attributes. On the other hand, the avarage characteristics are very difficult to define for the mixture of serpentinic and fine grained granitic materials because of the varied degree of mixing of these two. Hence, it is highly possible that some samples are allocated into one of the end-member groups of soil material, to which the sample is statistically closer than to the average characteristics of the mixture, even if it is actually the mixture of the two different soil materials.

Figure 7-5 shows on a map the results of sample allocation by discriminant analysis, together with the delineation of soil materials established by field observation and air-photo interpretation by the surveyor. The geographical distribution of samples belonging to a certain soil material group concurs with the delineations made by the surveyor. The profiles which were misclassified by the numerical method are located in the transitional

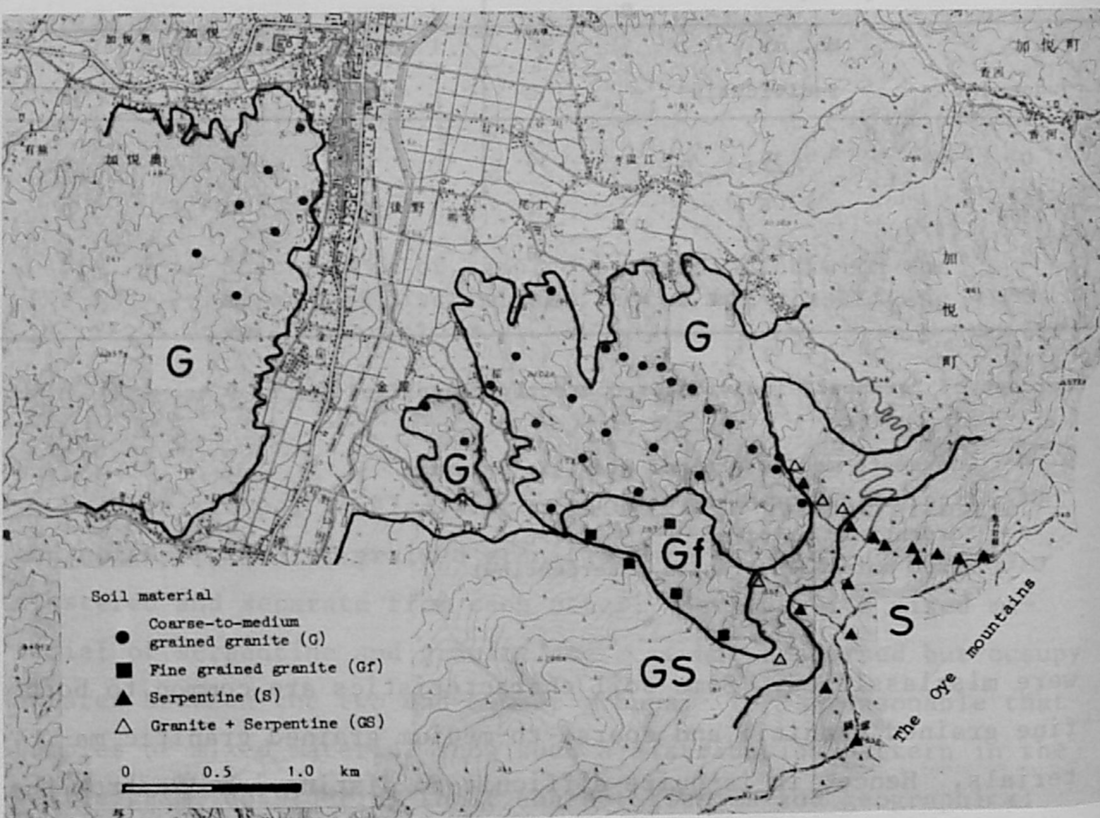


Fig. 7-5 Comparison between numerical and conventional classification of soil material

area between two different soil material zones. Indeed they were very difficult for the surveyor to classify in the field as well.

Clay mineral compositions of the four soil materials were examined by X-ray diffraction analysis. Potassium- and magnesium-saturated parallel orientation clay specimens of representative samples, which were allocated into four different soil materials by the numerical procedure, were prepared and examined semi-quantitatively under different treatments, such as air drying (KAD) and heating at 300°C (K300) and 550°C (K550) for the potassium-saturated specimen and air drying (MgAD) and glycerol solvation (MgGly) for the magnesium-saturated one. Figure 7-6 shows X-ray diffractograms for those samples. Clay mineral compositions of the four soil materials are summarized in Table 7-11.

Serpentinic material contains chlorite mineral resulting from weathering of serpentine. On the other hand, granitic materials both fine grained and coarse-to-medium grained, have a generally similar composition, and show a prominent peak of kaolin minerals

Table 7-11 Clay mineral composition of sampled soils representative of soil material groups

Sample	Clay minerals				
	Mt	Vt	Ch	It	K
260-B	-	++(Al)	++	+	++
65-B_2	-	++(Al)	+	-	+++
34-B	-	+(Al)	-	-	+++
270-B_2	-	$\pm$	-	-	+++

Mt ; Montmorillonite
Vt ; Vermiculite
(Al) : including Al interlayered vermiculite
Ch ; Chlorite
It ; Illite
K ; Kaolin minerals

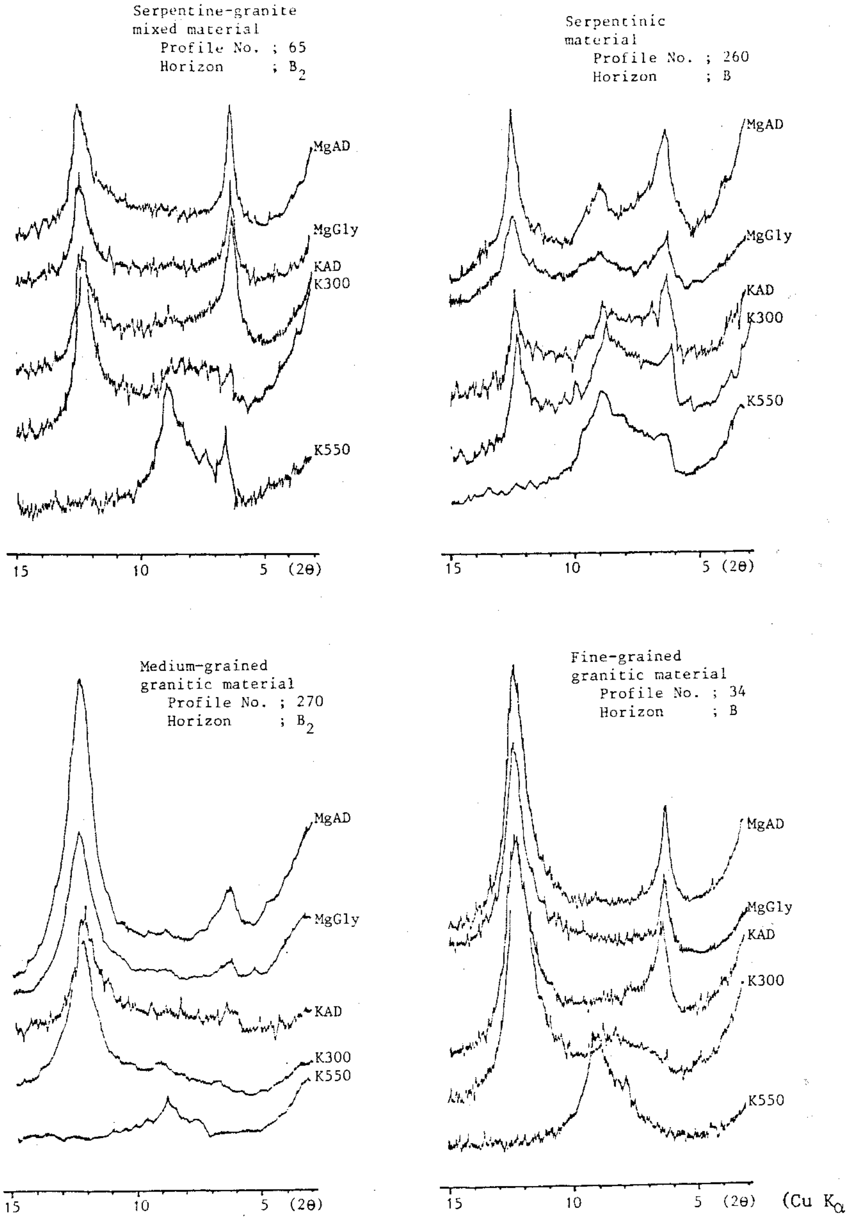


Fig. 7-6 X-ray diffractogram for clay fractions of sampled soils representative of soil materials

but no chlorite peak. Mixed material of serpentine and granite shows an intermediate pattern between the above two and shows a small peak of chlorite. Although hardly any difference can be seen between the fine grained and the coarse-to-medium grained granites in their clay mineral composition, a remarkable difference is seen in their soil texture: clay loam for fine grained granite and sandy loam for coarse-to-medium grained granite. Hence, the results of sample allocation by the numerical method were supported by the fact that the clay mineral composition and the particle size distribution pattern of a sample from a certain soil material differed clearly from the other samples.

The author concludes that the numerical procedures which include soil material class establishment and sample allocation, successfully simulate the conventional procedures used by an experienced surveyor. Webster (1974) selected representative samples according to the surveyor's judgement for the derivation of discriminant functions for each of the soil series. In this study the representative samples were statistically chosen by Hayashi 3 analysis and the 90 % probability ellipses. Thus, the soil material classification was carried out without any biases of the surveyor, except the procedures of soil attribute selection and attribute-class setting. This study has proved that this procedure can reproduce the classification performed by a surveyor, provided soil attribute selection and attribute-class setting are thoughtfully done. This study makes it possible to identify soil material objectively and reproducibly when a sample is taken in the studied area or its surroundings and data such as those employed in this study are available.

CHAPTER 8 Automated Map Compilation

8.1 Introduction

Thematic maps and interpretation maps are compiled and published as part of the outcome of a soil survey. Such maps include many delineated areas, each of which is considered homogeneous with regard to certain characteristics of the soil. To define these delineated areas, there are three possibilities; the retrieval of polygon data based on associated soil characteristics, delineation of areas within a map based on the similarity of site data, and the combination thereof.

Defining delineated areas has so far been done by an experienced surveyor and, thus, has been time-consuming and somewhat subjective. If a computer automatically processes the raw data and gives results similar to the conventionally processed ones, then every user, even a non-specialist of soil survey, can obtain such maps in accordance with his interests.

As stated in Chapter 3, there are many papers which describe input-output procedures for thematic maps which have already been conventionally prepared. However, very few papers deal with methods of map preparation using raw data, including site and polygon data. Cameron and Toogood (1970) and Davies and Roberts (1976) prepared contour maps on nutrient status and trace element status, respectively, by using site data. Campbell (1978) and Webster and Burrough (1972) employed discriminant analysis and similarity analysis, respectively, to locate the boundaries between soil series. Bie et al. (1978) produced a map showing payment classes for water charges from site and polygon data by the use of a discrete approach (de Gruijter and Bie, 1975).

COSMAS is equipped with some programs aiming at fast, objective and reproducible representation of soil data in map form.

In this study, an applicability of these programs and statistical data manipulation is tested for automatic compilation of a soil map and a suitability map for upland crop cultivation on lowland for an example of interpretation maps.

8.2 Compilation of Soil Map

A soil map shows a distribution of different kinds of soils, each of which has its unique characteristics as compared to the others. A surveyor compiles a soil map by the following steps:

1. taxonomic class establishment ,
2. sample allocation into one of the classes, and
3. defining mapping units and area delineation for each of these units by the information obtained in step 2 for every sampled site.

The first two steps can be replaced by numerical classification procedures. For the third step, COSMAS's "AUTOMAP" program is employed for delineating homogeneous subareas within a map.

8.2.1 Soil survey and employed data

The study area was in Kaya Township, Kyoto Prefecture. In the lowland of Kaya Township, 156 profiles were investigated with the survey procedure standardized in Chapters 2 and 3. Observation pits were distributed at a density of one per 4 ha. For those profiles, site descriptions, horizon descriptions and analytical data are available through COSMAS.

Four soil types were distinguished by a surveyor in the lowland of the study area: Gley Lowland Soil (GLL), Gray Lowland Soil (GRL), Brown Lowland Soil (BLS) and Pseudogley Soil (PSG). The soil attributes to be employed here must be selected so that they distinguish these four soil types most effectively. Such soil attributes coincide with those used in the conventional classification of soil type by a surveyor and are: land form, slope, water table, surface drainage, internal drainage, soil drainage (combination of surface drainage and internal drainage), accumulation, consistency (dry), stickiness, plasticity, color (hue, value, chroma), air-phase percentage, ferrous ion and soil texture.

8.2.2 Method of data handling

8.2.2.1 Numerical classification of soil type

First of all, we must numerically eatablish taxonomic classes. The author applied Hayashi's theory of quantification No. 3 (Hayashi 3) to the classification of soil material in Chapter 7 and concluded that it can reproduce the surveyor's procedure of class establishment. After taxonomic classes are established, the samples are allocated into them. Discriminant analysis is the most popular and appropriate method for this task as stated in Chapter 7.

Thus, the author employed Hayashi 3 analysis and discriminant analysis in combination for numerically classifying samples in terms of taxonomic class (soil type). All computation was carried out by the subprograms of SPSS, "HAYASI 3" and "DISCRIMINANT."

8.2.2.2 Program "AUTOMAP"

The outcomes of numerical classification of sample profiles in terms of soil type are point data. To form a soil map showing the distribution of some different kinds of soil, these data must be compiled into homogeneous polygons, i.e. subareas. In such a situation, COSMAS's "AUTOMAP" program was used for automatically converting point data to polygon data.

8.2.3. Results

8.2.3.1 Taxonomic class establishment

Hayashi 3 starts with setting up attribute-classes for each of the selected soil attributes. Threshold values which define those attribute-classes were assigned so as to differentiate the soil types. Hayashi 3 was performed on 156 soil profiles using 39 attribute-classes of 16 soil attributes as shown in Table 8-1.

Table 8-2 and 8-3 show the results of quantification of attribute-classes and individual soil profiles, respectively. As shown in Table 8-4, eigenvalues from which the first two numerical values were derived explain 33.9 % of the total variance. The contribution of lower-order eigenvalues are relatively small compared to the first two. Thus, in order to establish the taxonomic classes, every profile was plotted in two dimensional space, using

Table 8-1 Attribute-class list for soil type classification

Attribute \ Class	I	II	III	unit
Land form	1 - 14	15 - 16	17 - 20	(code)
Slope	0 - 5	5 <	-	degree
Water table	0 - -100	-100 >	-	cm
Surf. drainage	pond.-slow	med.-v.rapid	-	-
Int. drainage	none-slow	med.-v.rapid	-	-
Soil drainage	v.poor-inperf.	mod.-excess	-	-
Accumulation	none	weakly-strongly	-	-
Consistency(dry)	loose-v.friab.	friab. -hard	-	-
Stickiness	non-moderate.	strongly	-	-
Plasticity	non-moderate.	strongly	-	-
Color (hue)	5YR - 10YR	2.5Y - 5Y	7.5Y - 10BG	Munsell
(value)	1 - 3	4	5 - 8	-
(chroma)	1 - 2	3	4 - 8	-
Air phase %	0.0 - 5.0	5.0 - 20.0	20.0-100.0	%
Ferrous ion	none	slow-moderate.	immediately	-
Soil texture	S,LS,SL,L,SiL	CL,SCL,SC	SiCL,LiC,SiC,HC	-

Table 8-2 Numeric values assigned to soil attribute-classes for soil type classification

Attribute	Class	Solution 1	2	3	4	5
Land form	I	2.533	-0.398	1.332	0.540	-0.578
	II	0.314	-0.290	-2.741	0.103	-0.823
	III	-1.138	0.265	0.629	-0.276	0.564
Slope	I	-1.228	0.680	1.120	0.196	1.217
	II	1.142	-0.651	-1.039	-0.206	-1.148
Water table	I	0.514	-0.575	-0.482	-0.784	-0.079
	II	-1.036	1.120	0.978	1.519	0.149
Surface drainage	I	-0.447	0.480	-0.190	0.425	0.638
	II	1.843	-1.068	-0.155	-0.865	-1.936
Internal drainage	I	0.663	1.224	0.009	0.213	-0.399
	II	-0.995	-1.824	0.005	-0.342	0.584
Soil drainage	I	0.347	1.849	0.183	0.189	-0.908
	II	-0.314	-1.624	-0.146	-0.186	0.787
Accumulation	I	0.123	0.665	0.091	-1.540	-1.331
	II	-0.146	-0.739	-0.083	1.657	1.447
Consistency (dry)	I	-1.071	-1.006	0.708	-0.292	-0.546
	II	0.856	0.802	-0.560	0.216	0.438
Stickiness	I	-0.821	-0.194	-0.305	-0.164	-0.396
	II	2.727	0.622	1.054	0.500	1.317
Plasticity	I	-1.080	-0.438	-0.039	-0.156	-0.734
	II	2.008	0.803	0.095	0.260	1.370
Color (hue)	I	0.771	-1.612	-0.226	-0.963	0.685
	II	-0.779	0.247	-0.387	3.446	-2.175
	III	-0.511	2.186	0.695	-1.537	0.822
Color (value)	I	-0.267	-0.977	-3.867	0.827	1.812
	II	-0.587	0.660	-0.323	-1.202	0.528
	III	0.814	-0.515	1.736	1.202	-1.284
Color (chroma)	I	-0.615	0.679	-0.857	-0.079	0.085
	II	0.580	-1.789	0.909	1.350	4.840
	III	1.641	-1.347	2.310	-0.422	-2.490
Air phase %	I	0.429	0.483	-0.561	0.031	0.186
	II	-0.808	-0.757	0.944	0.264	-0.098
	III	-1.335	-3.409	3.405	-5.163	-2.590
Ferrous ion	I	0.429	-1.384	0.397	-0.174	0.653
	II	-0.499	0.895	-1.090	3.169	-1.382
	III	-0.605	2.649	0.869	-3.515	0.379
Texture	I	-1.465	-0.384	2.782	0.495	-0.576
	II	-0.504	-0.171	-2.217	-0.569	-0.568
	III	2.410	0.675	0.640	0.337	1.554

Table 8-3 Numeric values assigned to profiles for soil type classification

Profile No.	Soil type* (field judgement)	Numeric values 1	2	3	4	5
48	3.	-0.4732	-0.2194	-0.3893	0.0586	-0.4151
60	1.	-0.6835	0.4925	0.3985	-0.4448	0.0014
61	1.	-0.5089	0.7100	0.0654	-0.4788	-0.0635
62	3.	-0.4732	-0.4897	-0.2971	0.3052	0.0961
64	1.	-0.5454	0.0174	0.0430	-0.3850	0.1919
68	3.	-0.3720	-0.0963	-0.3727	0.1261	-0.2679
70	1.	-0.6554	0.6131	0.4990	-0.3922	-0.0830
71	3.	-0.2445	-0.6558	0.3017	-0.2803	-0.2023
72	3.	-0.3356	-1.0069	0.4693	-0.2147	0.2123
73	3.	-0.3265	-0.7636	0.6234	0.0038	-0.0177
74	3.	-0.5703	-0.5502	0.2751	-0.1336	0.2747
75	3.	-0.6708	-0.4927	0.6549	-0.3877	-0.0500
76	3.	-0.3660	-0.6090	0.0548	0.0460	0.2133
77	3.	0.2636	-0.8063	0.1822	-0.2910	-0.5297
78	2.	-0.2746	-0.1986	0.5520	0.5483	0.3491
113	2.	-0.7529	-0.1064	0.2223	0.3382	0.1171
114	2.	-0.5395	-0.1672	-0.1926	0.1631	0.1491
115	1.	0.3702	0.7666	0.1029	-0.2033	0.4001
116	3.	-0.3854	-0.6096	-0.4777	-0.0562	0.2022
117	3.	0.0508	-0.1466	-0.8755	-0.1887	-0.0564
118	3.	0.3335	-0.3506	-0.6131	-0.0324	-0.0264
119	4.	1.2549	0.0637	0.2951	-0.0860	-0.3066
120	3.	0.6286	-0.1726	-0.1891	-0.0293	0.2596
121	4.	0.9889	-0.2100	0.2206	-0.3052	-0.1384
122	3.	-0.1192	-0.5171	-0.0866	-0.4262	-0.1666
123	4.	1.2369	-0.0299	0.2836	0.1271	-0.1215
124	3.	-0.2094	-0.3613	-0.5547	-0.3949	-0.1421
125	3.	-0.0948	-0.5795	-0.3849	-0.2918	0.2048
126	3.	0.3058	-0.6968	-0.2566	-0.1013	-0.2924
127	3.	0.8983	-0.4253	0.2677	0.1308	0.2552
128	3.	0.7139	-0.3134	0.0954	0.2347	0.5448
129	3.	0.2288	-0.3929	0.3988	-0.1203	-0.4841
130	3.	-0.0809	-0.2408	-0.6392	-0.3610	-0.0765
131	3.	-0.3177	-0.5703	-0.4122	-0.2633	0.0568
132	3.	-0.3216	-0.2045	-0.1603	-0.1451	0.2543
133	3.	0.7778	-0.1247	-0.3111	-0.0713	0.2916
134	3.	0.6170	-0.2210	-0.1805	-0.1916	-0.2195
135	3.	0.3460	-0.2841	-0.6092	-0.1398	0.3135
136	3.	-0.2535	-0.2490	-0.3847	0.1024	0.0506
137	3.	-0.4486	-0.4229	-0.0589	-0.1863	0.2219
138	4.	1.2033	-0.0267	0.3015	-0.0915	-0.2466
139	3.	0.0971	-0.5990	-0.8048	-0.1033	0.0620
140	2.	0.0403	0.0943	0.1876	0.2340	-0.7117
141	3.	-0.6082	-0.3469	0.1923	0.2957	-0.0150
142	2.	-0.4266	-0.3547	0.2443	0.7296	0.0596
143	3.	-0.0972	-0.5896	-0.5041	-0.3585	-0.0863
144	3.	-0.3243	-0.6143	-0.0446	-0.5344	-0.5189
145	1.	-0.5886	0.2543	0.3042	-0.3545	0.0327
146	3.	-0.4252	-0.3950	-0.1605	-0.1798	0.3157
147	1.	-0.0386	0.4339	-0.2439	-0.3710	-0.3379
148	4.	1.0081	-0.1980	0.0648	-0.1544	0.4307
149	2.	-0.4823	-0.1886	0.2578	0.1500	-0.3253
151	3.	-0.0819	-0.5195	-0.2643	-0.0839	0.5266
152	4.	1.0645	-0.0200	0.0469	-0.1198	-0.2621
153	2.	-0.0590	0.3540	-0.6567	0.1933	-0.5043
154	1.	-0.6932	0.0142	0.4414	0.1687	-0.0939
155	3.	-0.2141	-0.3167	-0.4504	-0.1244	0.2905
156	2.	0.1810	0.1833	-0.6316	0.7231	0.1339
157	2.	0.3192	0.2945	-0.7023	0.6026	0.0137
158	2.	0.9821	0.3373	0.1611	-0.1059	-0.0772
159	3.	0.2151	-0.6620	-0.0460	-0.1250	-0.2057
160	2.	0.3602	0.3849	-0.2083	0.2853	-0.1097
161	2.	-0.3147	0.3842	-0.3220	0.3946	-0.0962

Table 8-3 (cont'd)

Profile No.	Soil type * (field judgement)	Numeric values 1	2	3	4	5
162	1.	-0.4548	0.5980	0.1493	0.2936	0.1048
163	1.	-0.8042	0.1095	0.4244	-0.1995	0.3030
164	2.	-0.2371	0.1252	0.1072	-0.0268	0.1776
167	1.	-0.0881	0.6707	-0.2351	-0.0907	0.0490
168	3.	-0.4252	-0.3950	-0.1605	-0.1798	0.3157
169	1.	-0.1935	0.5197	-0.1149	0.0336	-0.1957
170	2.	-0.4017	-0.1761	-0.1485	-0.0041	0.3914
171	2.	-0.3132	0.4489	-0.1270	0.3787	0.2568
172	1.	0.6423	0.5832	-0.1886	0.1563	-0.0590
173	3.	-0.2572	-0.5805	-0.5171	-0.0781	0.2481
174	2.	0.0064	-0.5643	-0.5942	-0.1269	0.1488
175	1.	-0.4682	0.5764	0.2707	-0.4997	-0.0344
176	3.	0.7565	0.0727	0.0101	-0.1739	-0.0057
177	1.	-0.3672	0.4911	0.2212	0.5555	-0.3693
178	2.	-0.5925	0.3874	-0.0466	0.3215	-0.3348
179	1.	-0.3699	0.6860	-0.0898	-0.1822	0.0193
180	2.	-0.6962	0.2303	0.0100	0.1752	0.0875
181	1.	-0.4446	0.7953	0.2827	-0.3240	0.0413
182	1.	0.0875	0.8331	0.0659	-0.4518	0.2917
183	1.	-0.3846	0.8086	-0.0298	-0.3905	0.0418
184	2.	0.0612	0.4763	-0.0445	0.3971	0.2838
185	2.	-0.4199	-0.5301	0.4822	0.2702	0.5134
186	2.	0.3157	0.3274	0.0899	-0.0252	0.6955
187	2.	-0.4201	0.0867	-0.2464	-0.0368	0.3753
188	3.	0.6722	-0.1739	0.1124	0.1983	0.5292
189	3.	0.6174	-0.6324	0.0600	-0.1446	0.1128
190	4.	1.0846	-0.3212	0.3750	-0.1003	-0.1584
191	4.	1.1091	-0.1919	0.3847	0.1229	-0.0908
192	3.	0.1867	-0.9073	0.4838	-0.0246	-0.3567
193	3.	0.8632	-0.2280	0.0133	0.1381	0.1783
194	3.	-0.1965	-0.5946	0.0074	-0.4116	-0.1843
195	4.	1.0415	-0.3568	0.3602	-0.1467	-0.2022
196	4.	0.9632	0.1759	0.3906	0.1330	-0.0715
197	3.	-0.0787	-0.5880	-0.0640	-0.0760	-0.0678
198	3.	0.0119	-0.4134	0.3547	-0.1747	-0.3418
199	2.	-0.3671	0.3817	-0.2756	0.2819	-0.4649
200	2.	-0.3475	0.1983	-0.2727	0.1525	-0.4968
201	3.	-0.1981	-0.5638	-0.1585	-0.1229	0.6334
202	4.	0.5316	0.4220	-0.2278	0.6965	0.2841
203	3.	-0.1464	-0.8704	0.4758	-0.7649	-0.5015
204	2.	0.7253	0.4188	0.1826	0.4301	-0.0894
205	2.	0.0456	0.3387	0.3074	0.4365	0.3372
206	4.	1.1864	-0.1145	0.2906	0.1083	-0.0731
207	2.	0.5307	0.1882	-0.2593	0.4653	-0.2248
208	3.	-0.5719	-0.4431	0.3646	0.3271	0.0054
209	2.	-0.4408	0.0863	0.5816	0.7167	-0.4359
210	3.	-0.1299	-0.6444	-0.2912	0.1785	-0.3895
211	4.	1.0601	0.0700	0.2993	-0.0109	-0.0858
212	4.	0.9357	-0.2624	0.1804	0.2762	0.6519
213	4.	0.3848	0.1467	0.3616	-0.0823	-0.8143
214	2.	-0.1302	0.0602	-0.7166	0.5515	-0.4586
215	2.	-0.1525	0.2113	-0.2871	0.0149	-0.5095
216	2.	-0.3127	0.1488	0.1867	0.5846	-0.1730
217	3.	-0.5278	-0.4638	0.6538	0.4496	-0.1413
218	2.	-0.7395	-0.1760	0.3381	0.1210	-0.0407
219	1.	-0.4129	0.3568	0.4610	0.0033	-0.1163
220	1.	-0.4380	0.6858	0.1602	0.0938	-0.0687
221	1.	0.4770	0.5607	-0.0161	-0.0989	-0.1391
222	1.	0.5340	0.6281	-0.0362	-0.1779	0.0740
223	2.	-0.3920	0.3068	-0.2279	0.4092	-0.1139
224	3.	-0.4003	-0.7135	0.4850	0.1408	0.4814
225	2.	-0.1523	0.2561	-0.0896	0.1361	-0.2558
226	1.	0.3800	0.7230	0.2686	-0.0603	0.4591

Table 8-3 (cont'd)

Profile No.	Soil type* (field judgement)	Numeric values 1	2	3	4	5
227	2.	-0.5894	-0.1039	-0.0436	0.5989	-0.0893
228	1.	-0.4619	0.7311	0.0643	-0.3759	0.0241
229	2.	0.7810	0.5765	0.0660	0.1836	-0.0436
230	2.	0.7002	0.2975	-0.0445	0.4254	0.2439
231	2.	-0.2653	0.1222	-0.4519	0.2632	0.1161
232	2.	-0.5316	-0.1029	0.4442	0.1913	0.2684
233	1.	-0.4446	0.7953	0.2827	-0.3240	0.0413
234	4.	0.8654	-0.2401	0.0923	0.2523	-0.2014
235	3.	0.5454	-0.3548	-0.0476	0.0375	0.5710
236	1.	-0.4780	0.4403	0.2216	-0.1363	0.1318
237	1.	0.0249	0.5072	0.0679	-0.2558	-0.4673
238	1.	0.0473	0.7682	-0.3670	-0.3660	-0.0612
239	1.	0.2123	0.9901	0.2421	-0.2664	0.4130
240	1.	-0.1916	0.8862	-0.0214	-0.3645	0.1733
241	2.	-0.3222	0.5424	-0.1322	0.3329	-0.1855
242	3.	-0.5626	-0.4858	0.2460	-0.0987	0.2974
243	1.	0.0102	0.7557	0.1600	-0.4372	0.2740
244	2.	-0.7100	-0.1070	0.3738	0.4802	-0.2812
245	2.	-0.3027	0.3925	-0.0727	0.0919	0.1434
246	1.	0.3291	0.7819	-0.0709	-0.2835	0.4791
247	2.	-0.3261	0.2610	0.3033	0.5464	-0.0685
249	1.	0.0875	0.8331	0.0659	-0.4518	0.2917
250	1.	-0.4082	0.5897	-0.0418	-0.5662	-0.0339
251	2.	0.2674	0.4057	-0.1844	-0.1524	-0.4502
252	1.	-0.4548	0.4642	0.1541	-0.4614	-0.1389
253	3.	-0.1927	-0.0609	-0.0111	0.0286	0.0350
254	4.	1.2033	-0.0267	0.3015	-0.0915	-0.2466
255	3.	0.1581	-0.2246	-0.0828	-0.2757	0.3022
256	3.	-0.0228	-0.1991	-0.4802	-0.3000	-0.1101
257	3.	-0.1593	-0.5762	-0.2725	-0.2162	-0.2234

* Soil type

1 : Gley lowland soil
2 : Gray lowland soil
3 : Brown lowland soil
4 : Pseudogley soil

Table 8-4 Eigenvalues, correlation coefficients and cumulative ratios of total variance derived from "Hayashi 3" analysis for soil type classification

	Eigenvalue	Correlation coefficient	Cum. ratio of total variance
1	0.278	0.527	0.189
2	0.219	0.468	0.339
3	0.114	0.338	0.417
4	0.092	0.304	0.480
5	0.083	0.288	0.536

the first two numerical scores assigned to individuals as coordinates as shown in Figure 8-1. Each of the samples was plotted on the scattergram with the soil type label assigned in the field by the surveyor. An ellipse shows the statistical boundary within which 80 % of the population are expected to fall. This was drawn using the mean, standard deviation and variance of the numerical scores assigned to the profiles belonging to one group as shown in Table 8-5.

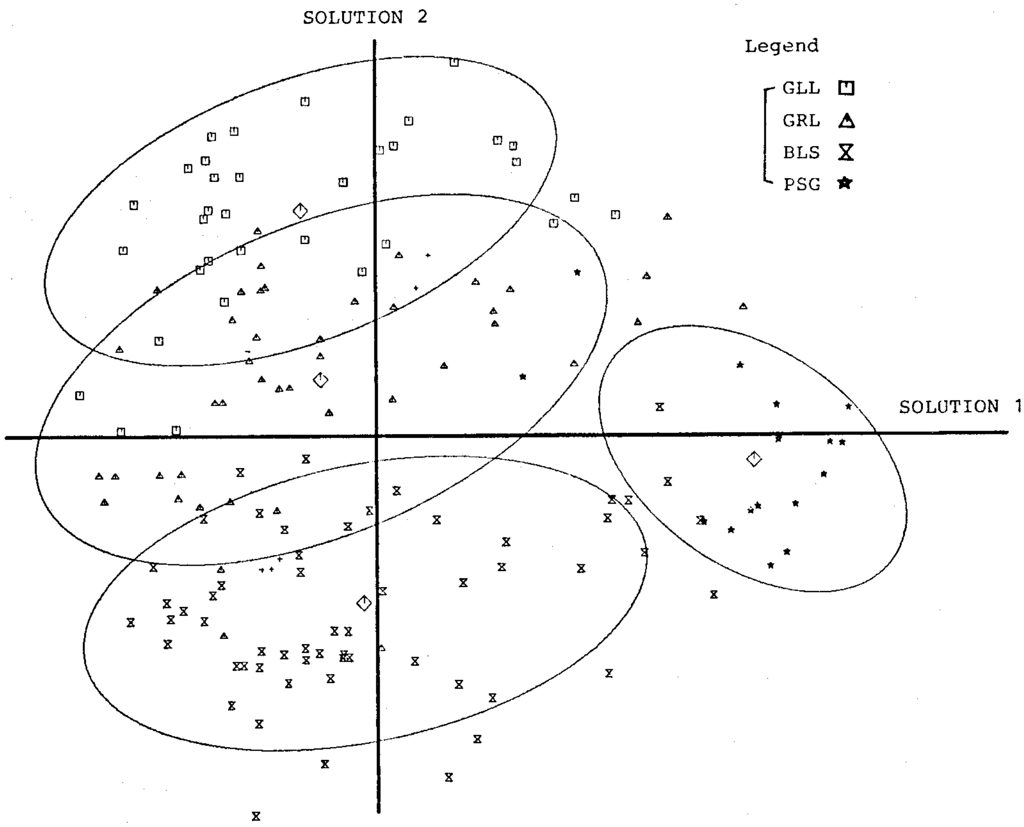


Fig. 8-1 Scattergram of sampled sites plotted with the first two numeric scores assigned by "Hayashi 3" for soil type establishment

Table 8-5 Statistics for each soil type

Soil type	Statistics	Solution 1	2	3	4	5
GLL	mean	-0.205	0.596	0.110	-0.225	0.044
	variance	0.147	0.052	0.043	0.061	0.048
	s.d.	0.384	0.227	0.208	0.247	0.220
GRL	mean	-0.152	0.148	-0.043	0.292	-0.038
	variance	0.183	0.074	0.111	0.055	0.097
	s.d.	0.428	0.272	0.332	0.234	0.312
BLS	mean	-0.039	-0.445	-0.091	-0.091	0.048
	variance	0.178	0.047	0.134	0.042	0.082
	s.d.	0.421	0.217	0.366	0.205	0.287
PSG	mean	1.007	-0.066	0.237	0.031	-0.097
	variance	0.052	0.039	0.025	0.051	0.097
	s.d.	0.229	0.197	0.158	0.225	0.311

The 80 % ellipses occupy separate areas in the scattergram and most of the individuals are localized within one of these ellipses. Consequently, four soil types were established as taxonomic classes by means of Hayashi 3 analysis. They correspond to the four soil types which were differentiated by the surveyor in the field.

8.2.3.2 Sample allocation

Discriminant analysis was performed to allocate the individual into the appropriate soil type. The five numerical values assigned to the individuals by Hayashi 3 were employed as discriminating variables, and the 127 typical individuals which fell within one of the 80 % probability ellipses were used for deriving the discriminant functions.

Three discriminant functions were derived from three eigenvalues shown in Table 8-6. Each sample was given three discriminant scores and allocated into a group in which the sample has the highest probability of membership. Table 8-7 shows the prior probabilities which were used to compute the probability of membership in each soil type for the individuals. The results of soil

Table 8-6 Eigenvalues and relative percentages for derived discriminant functions for soil type classification

Discriminant function	Eigenvalue	Relative percentage
1	8.977	73.2
2	2.343	19.1
3	0.942	7.7

Table 8-7 Prior probabilities for respective soil types

	GLL	GRL	BLS	PSG
No. of sample	30	35	47	15
Prior probability	0.236	0.276	0.370	0.118

type assignment for the individuals were summarized in Table 8-8. Figure 8-2 shows a scattergram of individuals which were plotted with the first two discriminant scores, and a statistically computed territorial boundary for each soil type. As shown in Table 8-6, since the first two discriminant functions explain 92.3 % of the variance among soil types, the third discriminant function is negligible in representing the results of the analysis. In Figure 8-2 each individual is represented with the label which was assigned in the field by the surveyor. A comparison between field judgement and numerical assignment in the soil type classification is summarized in Table 8-9.

For 140 out of 156 profiles (89.7 %), the same soil type was assigned as in the field survey. The author concludes that the numerical procedure gives an objective and satisfactory results in classifying soil types of the individual soils.

Table 8-8 Numerical assignment of soil type for sample profiles

Profile No.	Soil type* Field judgement	Soil type* Numerical assignment	Probability of membership* 1	2	3	4	Discriminant scores 1	2	3
48	3	3	0.000	0.425	0.575	0.0	0.7957	2.1203	0.5307
60	1	1	1.000	0.000	0.0	0.0	-4.4131	0.2720	-2.0655
61	1	1	1.000	0.000	0.0	0.0	-5.2405	0.1919	-1.9152
62	3	3	0.0	0.002	0.998	0.0	2.5215	2.6698	1.1029
64	1	2	0.102	0.783	0.116	0.0	-0.9556	1.2402	-1.9551
68	3	2	0.000	0.925	0.075	0.0	0.2443	1.8021	0.7941
70	1	1	1.000	0.000	0.0	0.0	-5.1858	-0.1580	-1.7488
71	3	3	0.0	0.000	1.000	0.000	3.5298	0.2744	-1.4211
72	3	3	0.0	0.0	1.000	0.000	5.5150	0.8255	-1.6599
73	3	3	0.0	0.000	1.000	0.000	3.8881	0.2460	-0.4833
74	3	3	0.0	0.000	1.000	0.000	2.3876	1.5932	-1.2042
75	3	3	0.0	0.000	1.000	0.000	1.5364	0.6465	-2.2166
76	3	3	0.0	0.000	1.000	0.000	3.2593	1.6024	-0.2445
77	3	3	0.0	0.0	0.986	0.014	5.4134	-1.0432	-1.0545
78	2	2	0.000	0.972	0.028	0.000	0.6209	0.3048	1.8866
113	2	2	0.000	0.999	0.001	0.0	-0.6886	2.0553	1.1037
114	2	2	0.000	0.803	0.197	0.0	0.3462	2.2641	0.4987
115	1	1	1.000	0.000	0.0	0.0	-3.8736	-2.0820	-0.7239
116	3	3	0.0	0.000	1.000	0.0	3.5534	2.7224	-0.5205
117	3	3	0.0	0.003	0.997	0.000	1.6929	1.5774	-0.4524
118	3	3	0.0	0.000	1.000	0.000	3.3280	0.5000	0.1554
119	4	4	0.0	0.0	0.000	1.000	1.8593	-4.7955	0.3228
120	3	3	0.0	0.000	0.853	0.147	2.5727	-1.2820	-0.0096
121	4	4	0.0	0.0	0.000	1.000	3.1336	-3.6309	-0.9406
122	3	3	0.0	0.000	1.000	0.000	3.1509	0.5186	-1.8675
123	4	4	0.0	0.0	0.000	1.000	2.4545	-4.3641	1.0842
124	3	3	0.0	0.000	1.000	0.0	2.3150	1.6754	-1.5721
125	3	3	0.0	0.000	1.000	0.000	3.8468	1.4661	-1.4726
126	3	3	0.0	0.0	1.000	0.000	5.1401	-0.0572	-0.2009
127	3	4	0.0	0.0	0.004	0.996	4.3577	-2.7077	0.5544
128	3	4	0.0	0.000	0.332	0.668	3.4909	-1.6484	0.8243
129	3	3	0.0	0.000	0.558	0.442	2.6699	-1.6557	-0.2688
130	3	3	0.0	0.000	1.000	0.000	1.8755	1.4214	-1.3539
131	3	3	0.0	0.000	1.000	0.0	3.3613	2.1084	-1.3048
132	3	3	0.000	0.024	0.976	0.000	0.9781	1.4305	-0.8815
133	3	3	0.0	0.000	0.673	0.327	2.6363	-1.5201	-0.1076
134	3	3	0.0	0.000	0.624	0.376	2.7431	-1.6248	-0.3895
135	3	3	0.0	0.000	1.000	0.000	3.0057	0.5223	-0.5446
136	3	3	0.0	0.041	0.959	0.000	1.4826	1.8008	0.4412
137	3	3	0.0	0.000	1.000	0.0	2.0222	1.7537	-1.1973
138	4	4	0.0	0.0	0.000	1.000	2.3311	-4.5352	0.1996
139	3	3	0.0	0.0	1.000	0.0	4.5599	1.8582	-0.3379
140	2	2	0.000	1.000	0.000	0.000	-0.6043	-1.0038	1.6400
141	3	3	0.0	0.411	0.589	0.000	1.0594	1.8111	0.9895
142	2	2	0.0	0.883	0.117	0.000	1.4378	1.5171	2.8885
143	3	3	0.0	0.000	1.000	0.000	3.9169	1.5136	-1.5136
144	3	3	0.0	0.000	1.000	0.000	3.2684	0.8414	-2.2028
145	1	1	0.978	0.022	0.000	0.0	-2.6961	0.5046	-1.7145
146	3	3	0.0	0.000	1.000	0.0	1.9759	1.9367	-1.1878
147	1	1	0.938	0.062	0.000	0.0	-2.5185	-0.3700	-1.0663
148	4	4	0.0	0.0	0.005	0.995	3.3126	-2.9124	-0.6428
149	2	2	0.000	0.932	0.068	0.000	0.2068	0.8512	0.6639
151	3	3	0.0	0.000	1.000	0.000	3.4958	1.4541	-0.8116
152	4	4	0.0	0.000	0.000	1.000	2.1852	-3.6125	0.1254
153	2	2	0.001	0.999	0.000	0.0	-1.8297	0.9462	1.6381
154	1	2	0.003	0.997	0.000	0.0	-1.5066	1.0441	0.5116
155	3	3	0.0	0.000	1.000	0.0	2.0609	1.8769	-0.7259
156	2	2	0.0	1.000	0.000	0.0	-0.1991	1.1051	3.5057
157	2	2	0.000	1.000	0.000	0.0	-0.6123	0.5798	3.1797
158	2	4	0.000	0.001	0.000	0.999	-0.2109	-3.8354	0.1080
159	3	3	0.0	0.0	0.999	0.001	4.6430	-0.2355	-0.4583
160	2	2	0.001	0.999	0.000	0.000	-1.4339	-0.9853	1.7648
161	2	2	0.002	0.998	0.000	0.0	-2.6122	1.3517	2.0272
162	1	1	0.891	0.109	0.0	0.0	-4.4487	0.6047	1.3075
163	1	1	0.645	0.355	0.000	0.0	-2.2173	1.3026	-1.4057
164	2	2	0.010	0.988	0.002	0.000	-1.0835	0.3238	-0.2381
167	1	1	0.990	0.010	0.0	0.0	-3.9955	-0.0375	-0.0570
168	3	3	0.0	0.000	1.000	0.0	1.9759	1.9367	-1.1878
169	1	1	0.751	0.249	0.0	0.0	-3.3809	0.1025	0.5405
170	2	3	0.000	0.168	0.832	0.0	0.6772	1.7988	-0.3865
171	2	2	0.025	0.975	0.0	0.0	-3.0577	1.0717	1.6539

Table 8-8 (cont'd)

Profile No.	Soil type* Field judgement	Soil type* Numerical assignment	Probability of membership* 1	2	3	4	Discriminant scores 1	2	3
172	1	2	0.110	0.889	0.000	0.000	-2.1396	-2.1181	1.3281
173	3	3	0.0	0.000	1.000	0.0	3.6459	2.4099	-0.5816
174	2	3	0.0	0.000	1.000	0.000	4.0629	1.6799	-0.5953
175	1	1	1.000	0.000	0.0	0.0	-4.4598	-0.2363	-2.1297
176	3	4	0.000	0.001	0.013	0.986	1.1124	-2.5891	-0.3749
177	1	2	0.044	0.956	0.0	0.0	-3.7619	0.1878	2.7847
178	2	2	0.041	0.959	0.0	0.0	-3.3714	1.3885	1.6962
179	1	1	1.000	0.000	0.0	0.0	-4.7135	0.3925	-0.5811
180	2	2	0.021	0.979	0.000	0.0	-2.5433	1.8831	0.6218
181	1	1	1.000	0.000	0.0	0.0	-5.7584	-0.3742	-1.3284
182	1	1	1.000	0.000	0.0	0.0	-4.8169	-1.4667	-1.8017
183	1	1	1.000	0.000	0.0	0.0	-5.5363	0.0568	-1.4938
184	2	2	0.016	0.984	0.000	0.0	-2.5745	-0.2158	1.8334
185	2	3	0.0	0.001	0.999	0.000	2.4728	1.1121	0.3879
186	2	2	0.091	0.908	0.001	0.000	-1.1857	-1.1617	-0.3388
187	2	2	0.002	0.990	0.008	0.0	-0.9260	1.7764	-0.3966
188	3	4	0.0	0.001	0.251	0.749	2.5357	-1.7305	0.7065
189	3	3	0.0	0.0	0.837	0.163	5.2091	-1.5071	-0.6611
190	4	4	0.0	0.0	0.000	1.000	3.9043	-4.0071	-0.0807
191	4	4	0.0	0.0	0.000	1.000	3.1626	-4.0278	0.9039
192	3	3	0.0	0.0	0.965	0.035	5.7493	-1.0698	-0.1753
193	3	4	0.0	0.000	0.022	0.978	3.2140	-2.2912	0.7866
194	3	3	0.0	0.000	1.000	0.000	3.4243	0.6216	-1.8769
195	4	4	0.0	0.0	0.000	1.000	4.0429	-3.8720	-0.2758
196	4	4	0.0	0.000	0.000	1.000	0.6155	-3.9431	1.0146
197	3	3	0.0	0.000	1.000	0.000	3.6782	0.7244	-0.4198
198	3	3	0.0	0.000	0.989	0.011	2.4481	-0.8472	-0.6867
199	2	2	0.008	0.992	0.0	0.0	-2.8013	1.1062	1.7730
200	2	2	0.001	0.999	0.000	0.0	-1.6413	1.1090	1.1667
201	3	3	0.0	0.000	1.000	0.0	3.5088	1.6539	-1.1563
202	4	2	0.000	1.000	0.000	0.000	-1.2420	-0.9599	3.3606
203	3	3	0.0	0.0	1.000	0.000	4.8604	-0.7055	-3.4277
204	2	2	0.001	0.984	0.000	0.015	-1.1987	-2.8272	2.4050
205	2	2	0.005	0.995	0.000	0.000	-1.9588	-0.7294	1.7969
206	4	4	0.0	0.0	0.000	1.000	2.8891	-4.1307	0.9134
207	2	2	0.000	0.999	0.001	0.001	0.1122	-1.1372	2.6489
208	3	3	0.0	0.080	0.920	0.000	1.6196	1.4616	1.0345
209	2	2	0.000	1.000	0.000	0.0	-1.6287	0.0990	3.2514
210	3	3	0.0	0.000	1.000	0.000	4.0113	1.3998	0.9755
211	4	4	0.0	0.000	0.000	1.000	1.5021	-4.0434	0.4178
212	4	4	0.0	0.000	0.009	0.991	3.5589	-2.4447	0.9983
213	4	4	0.004	0.373	0.002	0.622	-0.4219	-2.7368	0.4133
214	2	2	0.0	1.000	0.000	0.0	-0.0907	1.8496	3.0648
215	2	2	0.003	0.997	0.000	0.0	-1.3549	0.4427	0.6513
216	2	2	0.000	1.000	0.000	0.0	-1.4795	0.5708	2.6704
217	3	3	0.0	0.242	0.759	0.000	1.6226	0.7275	1.5981
218	2	2	0.000	0.977	0.023	0.0	-0.3421	1.5860	0.2084
219	1	1	0.878	0.122	0.0	0.0	-3.1238	-0.2930	0.0221
220	1	1	0.998	0.002	0.0	0.0	-5.0068	0.2003	0.5937
221	1	1	0.853	0.147	0.000	0.000	-2.4372	-2.2020	0.1416
222	1	1	0.978	0.022	0.0	0.000	-2.6923	-2.3192	-0.3139
223	2	2	0.001	0.999	0.000	0.0	-2.3388	1.4547	2.0178
224	3	3	0.0	0.000	1.000	0.000	3.6328	1.1148	-0.2184
225	2	2	0.005	0.995	0.000	0.0	-1.6993	0.2158	0.9464
226	1	1	0.999	0.001	0.0	0.0	-3.6737	-2.2872	-0.2048
227	2	2	0.000	1.000	0.000	0.0	-0.2720	2.1926	2.5514
228	1	1	1.000	0.000	0.0	0.0	-5.2628	0.1598	-1.5033
229	2	2	0.162	0.834	0.000	0.004	-1.9937	-3.0408	1.4023
230	2	2	0.000	0.987	0.000	0.013	-0.2852	-1.9486	2.1540
231	2	2	0.000	0.999	0.001	0.0	-0.7773	1.7737	1.2534
232	2	2	0.000	0.988	0.012	0.000	-0.4068	0.9076	0.3538
233	1	1	1.000	0.000	0.0	0.0	-5.7584	-0.3742	-1.3284
234	4	4	0.0	0.000	0.002	0.998	3.1672	-2.6066	1.5447
235	3	3	0.0	0.000	0.975	0.025	3.5235	-0.9233	-0.0927
236	1	1	0.986	0.014	0.0	0.0	-3.5640	0.3861	-0.6936
237	1	1	0.986	0.014	0.0	0.0	-3.0717	-1.2957	-0.5129
238	1	1	1.000	0.000	0.0	0.0	-4.2932	-0.5127	-1.0576
239	1	1	1.000	0.000	0.0	0.0	-5.6355	-2.1628	-1.0309
240	1	1	1.000	0.000	0.0	0.0	-5.6337	-0.5118	-1.3823
241	2	2	0.185	0.815	0.0	0.0	-3.7423	0.7170	1.8172

Table 8-8 (cont'd)

Profile No.	Soil type*		Probability of membership*				Discriminant scores		
	Field judgement	Numerical assignment	1	2	3	4	1	2	3
242	3	3	0.0	0.000	1.000	0.000	2.0271	1.6086	-1.0318
243	1	1	1.000	0.000	0.0	0.0	-4.5435	-1.3637	-1.8111
244	2	2	0.000	1.000	0.000	0.0	-0.7788	1.4601	1.9936
245	2	2	0.203	0.797	0.000	0.0	-2.7520	0.7081	0.4428
246	1	1	1.000	0.000	0.0	0.0	-3.9224	-1.6105	-1.0888
247	2	2	0.001	0.999	0.000	0.0	-2.2500	0.2894	2.4224
249	1	1	1.000	0.000	0.0	0.0	-4.8169	-1.4667	-1.8017
250	1	1	1.000	0.000	0.0	0.0	-4.2376	0.1947	-2.2951
251	2	2	0.260	0.740	0.000	0.000	-1.8297	-1.2956	0.0610
252	1	1	1.000	0.000	0.0	0.0	-3.6893	0.0450	-1.8818
253	3	2	0.000	0.831	0.169	0.000	0.1954	0.5768	0.0985
254	4	4	0.0	0.0	0.000	1.000	2.3311	-4.5352	0.1996
255	3	3	0.0	0.000	0.999	0.000	1.9555	-0.2055	-1.3503
256	3	3	0.0	0.001	0.999	0.000	1.6219	0.8900	-1.0755
257	3	3	0.0	0.000	1.000	0.000	3.5490	1.2057	-0.8773

* Soil type

1 : Gley lowland soil (GLL)
2 : Gray lowland soil (GRL)
3 : Brown lowland soil (BLS)
4 : Pseudogley soil (PSG)

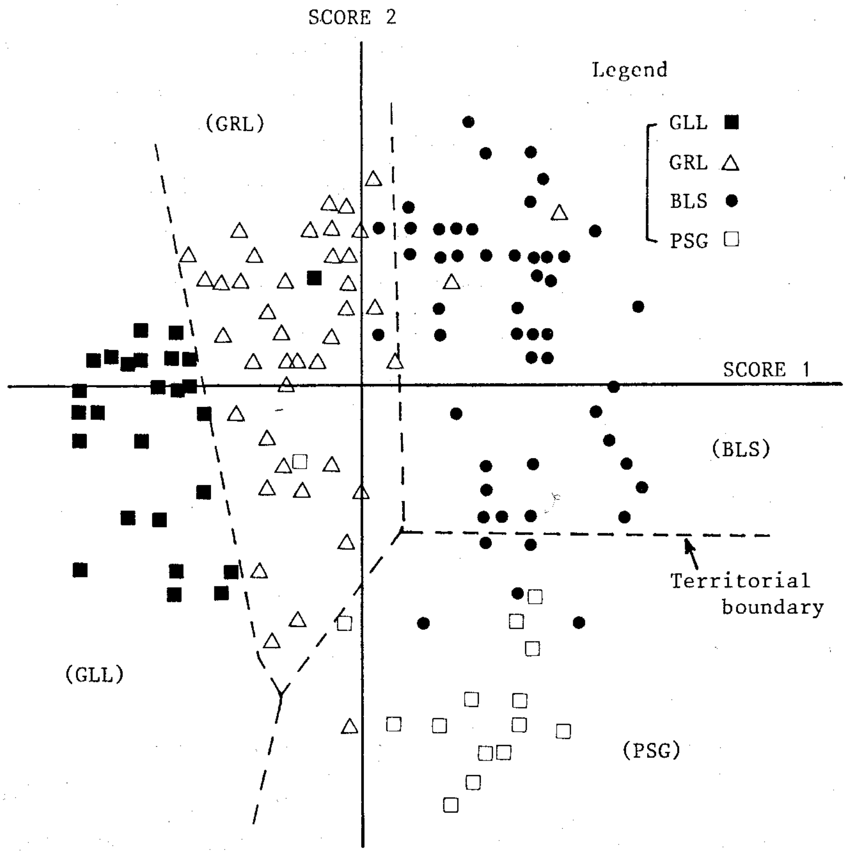


Fig. 8-2 Scattergram of sampled sites plotted with the first two discriminant scores for classifying soil type

Table 8-9 Cross-table between field judgement and numerical assignment on soil type classification

Field judgement	No. of individuals	Numerical assignment GLL	GRL	BLS	PSG
GLL	36	32	4	0	0
GRL	44	0	40	3	1
BLS	59	0	2	52	5
PSG	17	0	1	0	16

Percent of "grouped" individuals correctly classified : 89.7%

8.2.3.3 Area delineation

Numerically assigned soil type and the probability of membership for each sampling site were used to delineate areas which are homogeneous with respect to soil type. The mapping unit was identical with taxonomic unit in this study. The final map was automatically prepared by a printer plotter (VERSATEC 1200) which is one of the peripheral devices of the FACOM M-200 computer of Data Processing Center of Kyoto University. A soil map compiled by the numerical procedure is shown in Figure 8-3 (B) in comparison with the one compiled by the conventional procedure (A). The conventional soil map was herein recompiled on the basis of the difference in soil type.

8.2.4 Discussion and conclusion

The distribution pattern of each soil type is generally quite similar between (A) and (B). The numerically compiled soil map consists of more irregular, complicated and mosaic-shaped delineations than the other. This is because "AUTOMAP" has not yet been equipped with a function for recognizing "inclusions" unlike conventional map compilation. The surveyor

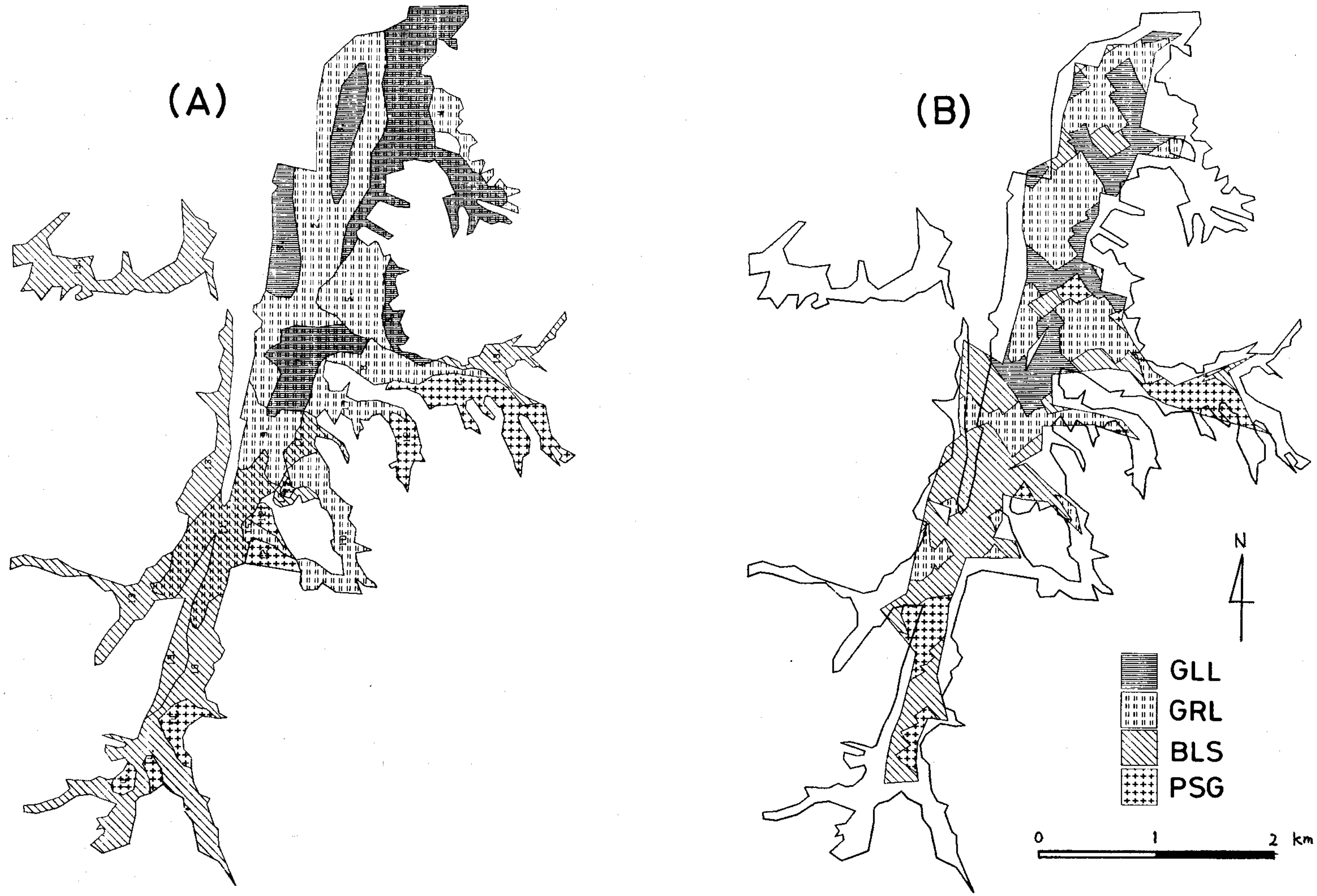


Fig. 8-3 Comparison between numerically and conventionally compiled soil maps

sometimes neglects an area around the site of soil type X and shows that area as being occupied by soil type Y, when soil type X occupies too small an area to delineate within the area of soil type Y at the given scale. Secondly, the program is not capable of setting up "soil complexes."

On the other hand, "AUTOMAP" makes the raw data available to a user; therefore, he can adjust them, if necessary, in accordance with his interest. Even a user who is not specialized in soil surveys can prepare a map showing the distribution pattern of any required data, raw or processed.

One thing must be mentioned here about the location of the boundaries. As shown in Figure 8-3, the exact locations of the boundaries are not identical between (A) and (B), because the method of compilation is entirely different. As the results of this study, if the numerically and conventionally compiled soil maps have similar distribution pattern of soil, the boundaries drawn in the conventional map are normally more reliable. However, the numerical method might make new boundaries in an area where no delineation occurs on the conventional map, and those boundaries might be of importance in compiling a map. The user himself is responsible for deciding which of the boundaries, conventional or numerical, should be adopted.

8.3 Compilation of an Interpretation Map - Suitability Map for Upland Crop Cultivation -

In order to serve to practical purposes, soil survey data are usually required to be compiled into interpretation maps. The compilation of a suitability map for upland crop cultivation on lowland paddy areas is described here as an example of interpretation map compilation. An interpretation map is not always compiled based on a single factor, which is derived from a soil attribute or a group of soil attributes. Hence, it comes out through overlaying of several assessment maps, which are prepared for each of the factors concerned. Compilation of the interpretation map is carried out through the following three steps;

1. selection of soil attributes relevant to the problem,
2. generation of an assessment map for each of the selected attributes or groups of attributes, and
3. class setting and overlaying of the assessment maps.

It is one of the biggest problems in agriculture of Japan to convert paddy rice cropping to upland crop cultivation in the lowland area because of an imbalance between a great deal of surplus of rice production and deficit of upland crops production such as wheat, soybean , vegetables, forage crops and so on. Ministry of Agriculture, Forestry and Fisheries of Japan made a proposal of conversion from paddy rice to upland crop cultivation on 390,000 ha out of total rice cultivated area of 2,881,000 ha and 439,000 ha (113%) was actually converted in 1979 (Agricultural Production Bureau, 1979; Statistics and Information Department, Ministry of Agriculture, Forestry and Fisheries, 1979). However, this policy is not always accepted unanimously by the farmers due to complicated socio-economic situations. Although many problems remain unsolved yet, the assessment of land suitability for conversion of the landuse should be the most basic and important task for a soil scientist, if an efficient utilization of the limited arable land of Japan should be aimed at.

8.3.1 Selection of soil attributes influencing soil suitability for upland crop cultivation

Three factors must be considered for an assessment of the suitability for upland crop cultivation.

1. Soil water regime
2. Soil tilth

3. Chemical fertility

Three factors are ranked in the above order in their importance, provided the suitability is determined in terms of the cost for adapting an area to upland crop cultivation.

The first is soil water regime, which affects oxidation - reduction condition of root zone of the cultivated crops. This factor is characterized by such soil attributes as ground water level, water content, ferrous ion content, soil color, mottles, and soil structure. This is the costliest factor to modify, because certain means of drainage must be installed to make the land suitable for upland crops.

Next is the tilth factor which is characterized by stoniness, structure and consistency, latter two being a function of soil texture.

Finally chemical fertility should be considered. It is rather easy and inexpensive to modify this factor in Japan as compared to the preceding two other factors. The assessment of the study area on the third factor is based on such soil attributes as cation exchange capacity, calcium saturation percentage, pH, exchangeable cations (K^+, Ca^{2+}, Mg^{2+}), available phosphorus and silica.

8.3.2 Generation of assessment maps

8.3.2.1 Soil water regime

The soil water regime is one of the most important differentiating characteristics of the four soil types; GLL, GRL, BLS and PSG. Therefore, polygon data, stored in Cartographic File of COSMAS, should better be used for the preparation of assessment map on this factor rather than site data, because it was shown in 8.2 that the conventionally compiled soil map was similar to the one prepared by numerical method based on site observations.

As shown in Table 8-10, three classes were set up by the use of two soil attributes which are stored in Cartographic File; soil type and variety. Figure 8-4 shows the map of suitability class in terms of soil water regime. This map was prepared by the use of the "MAP" program of COSMAS.

Table 8-10 Classes set for soil water regime assessment

Suitability Class	Soil Type	Soil Variety
I (good)	BLS	ALL
II (poor)	GRL	ALL
	PSG	
III (v.poor)	GRL	UG
	GLL	ALL

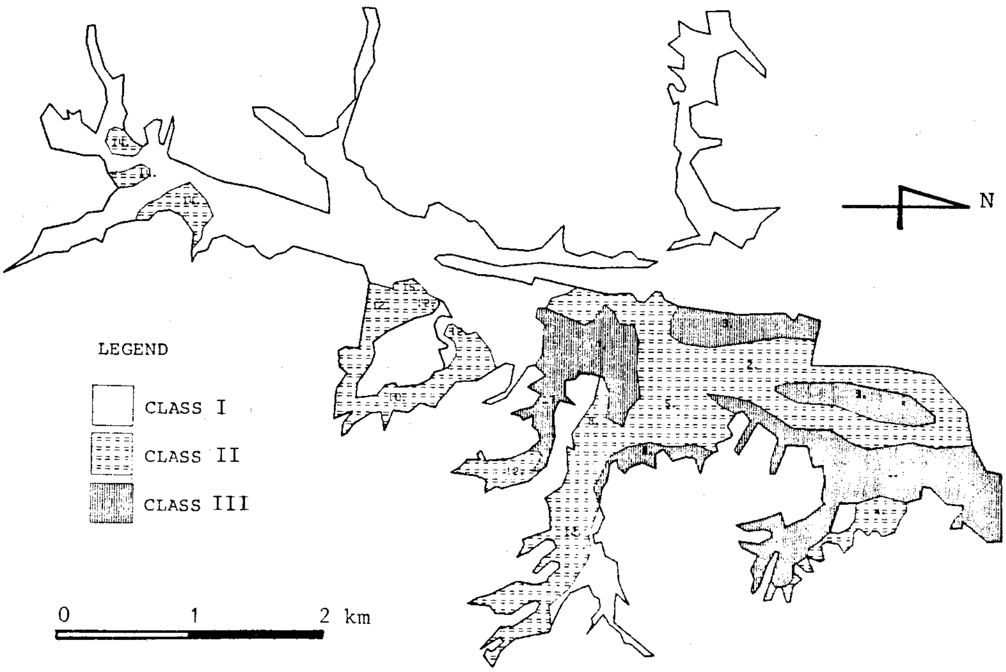


Fig. 8-4 Soil water regime map

8.3.2.2. Soil tilth

The assessment map on soil tilth can also be prepared from the polygon data through "MAP" program. As shown in Table 8-11, three classes were set up based on two soil attributes stored in COSMAS's Cartographic File; stoniness and texture class. Figure 8-5 shows the assessment map on soil tilth.

Table 8-11 Classes set for soil tilth assessment

Suitability Class	Stoniness	Texture Class
I (good)	none	M , C
II (poor-1)	CP,PM	M , C
III (poor-2)	none	F

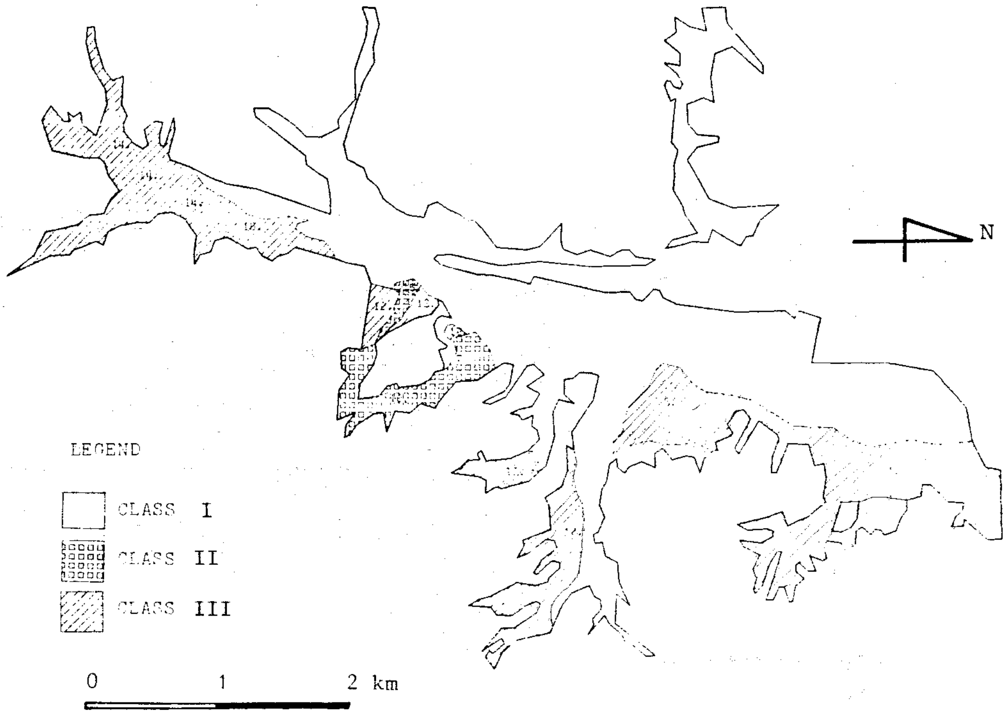


Fig. 8-5 Soil tilth class map

8.3.2.3. Chemical fertility

The data of soil attributes relevant to this factor are grouped into several classes according to the criteria used for the nation-wide soil survey of arable land by the Agricultural Production Bureau, Ministry of Agriculture, Forestry and Fisheries. Table 8-12 summarizes all classes for each of the soil attributes concerned. A tentative fertility class at an individual site is given as the class of a soil attribute which gets the lowest

Table 8-12 Classes set for chemical fertility assessment

Suitability Class	CEC (me)	pH	Ca sat. (%)	Exchangeable(mg)			Available(mg)	
				CaO	MgO	K_2O	P_2O_5	SiO_2
I	20.0<	5.5 <	50.0 <	200<	25<	15<	10<	15<
II	20.0-6.0	5.5-5.0	50.0-30.0	200 -100	25-10	15-8	10-2	15-5
III	< 6.0	< 5.0	< 30.0	<100	<10	< 8	< 2	< 5
(Example) III	I	II	III	I	II	II	II	I

assessment class among all the attributes used, as shown in an example of Table 8-12.

Tentative fertility classes for the individual sites were reclassified; class I (high fertility) for the tentative classes I and II, and class II (low fertility) for the tentative class III. Then, the assessment map was compiled by the use of "AUTO-MAP" program of COSMAS, and is shown in Figure 8-6.

8.3.3 Results

A suitability map for upland crop cultivation was produced by overlaying three assessment maps mentioned above. As the chemical fertility is easier to modify as compared to the other

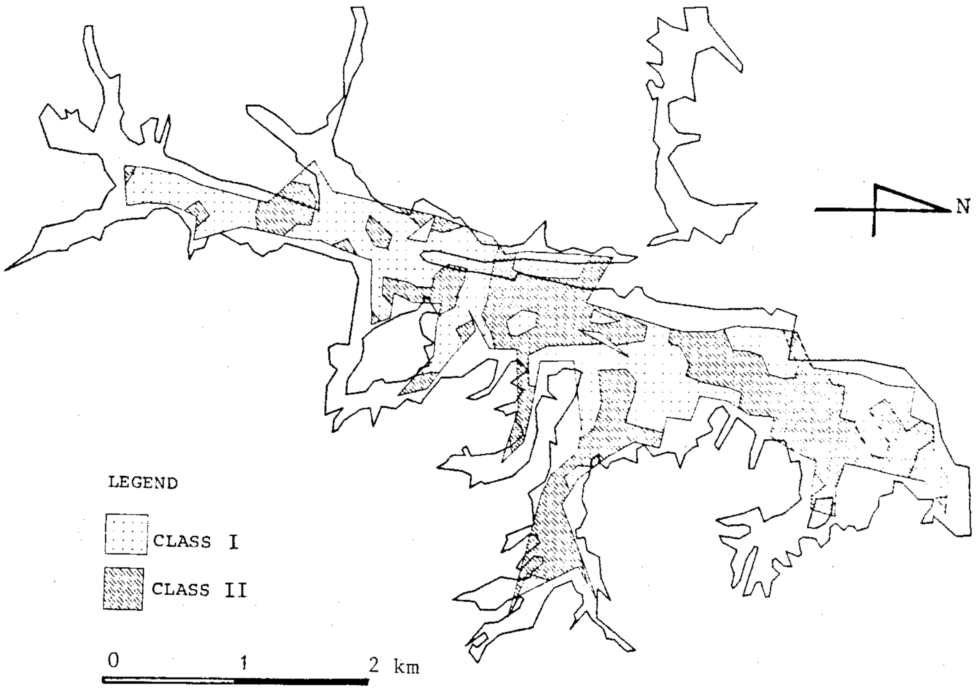


Fig. 8-6 Chemical fertility map

two factors, it was thought appropriate to take it up as a secondary factor. Therefore, suitability class was primarily determined by the other two factors; soil water regime and tilth. Three classes were set up, as shown in Table 8-13. Figure 8-7 shows the final output of a suitability map for upland crop cultivation on the lowland paddy area.

In this study area, class I is the most suitable land, where no problem may arise in converting the landuse from paddy to upland crop cultivation. Class II is poorly suitable land, which consists of two subareas: poorly drained area and area hard to plow. Hence, preparation of raised beds and stone removal, respectively, are advisable. Class III is very poorly suitable land because of too wet water regime, which would cause wet injury to crop roots. Installation of a drainage system is indispensable.

Table 8-13 Classes set for suitability assessment for upland crop cultivation

Suitability Class	Soil Water Condition	Tilth
I	good	good
II	poor	poor-1,2
III	v.poor	---

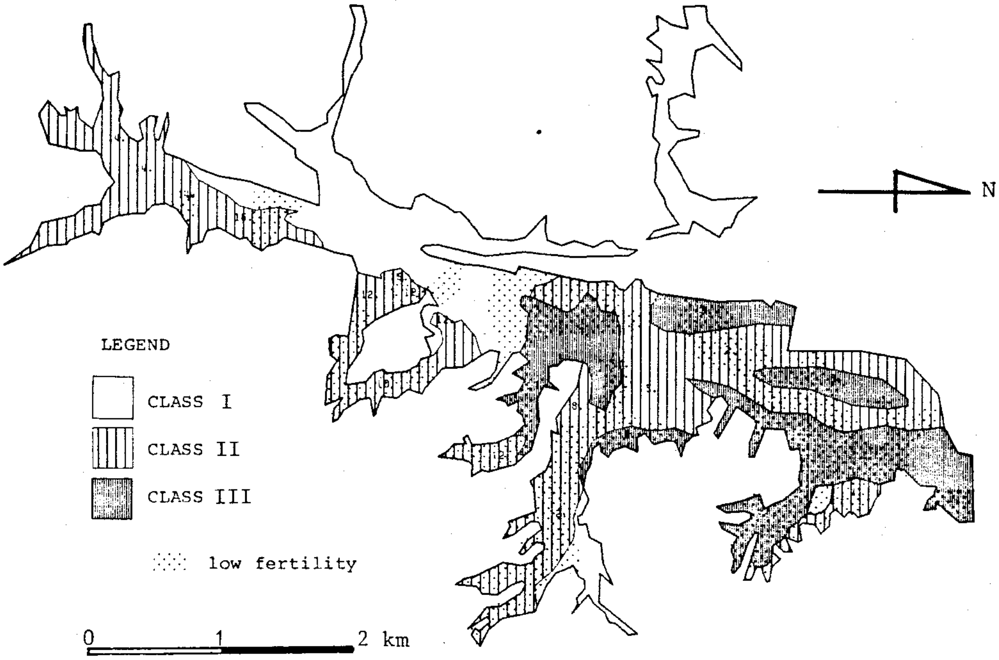


Fig. 8-7 Suitability map for upland crop cultivation

A secondary category as determined by chemical fertility status (high and low) is provided to each of the classes, as shown in Figure 8-7. Dotted areas, which have low fertility status, may be advised to adopt more intensive management of soil fertility.

8.3.4 Discussion and conclusion

An interpretation map has, hitherto, been compiled from a soil map, which is, in itself, a product of manipulation of raw data obtained in a soil survey. Thus, a lot of loss or distortion in original information is inevitable in the process of preparation of interpretation maps. It is preferable to make use of the raw or original data for preparing interpretation maps.

This study has proved that soil map and interpretation maps can be prepared as one of the output forms from raw data, site or polygon, stored in the files by the use of the functions of automated cartography of COSMAS. "AUTOMAP" program is now available for the procedure of site-polygon data conversion, which was used to be done by an experienced surveyor, giving high reproducibility and objectivity.

Consequently, even a user, who is not specialized in the soil survey, is able to prepare a map according to his interest. It was shown that any assessment map on a single factor could be automatically prepared by COSMAS's output programs. However, overlaying of several assessment maps cannot yet be automatically processed. Bie _et al_. (1978) employed a discrete approach (de Gruijter and Bie, 1975) as an example of the methods in solving this problem. This is one of the problems which should be solved by COSMAS in the near future.

CHAPTER 9 Summary and Further Research Needs

The aim of this case study was to test the applicability of COSMAS's functions for an efficient use of soil survey data on the fundamental and practical problems. Soil classification and map compilation have been carried out by an experienced surveyor accompanying certain subjectivity and variability. In order to avoid such drawbacks, search for appropriate methods of numerical classification of soils and automated map compilation were attempted in this study with some success.

9.1 Numerical Classification

Soil material classification and soil type classification were accomplished for soil samples obtained in the west slope of Mt. Oye and lowland area, respectively, in Kaya Township. Two numerical procedures, Hayashi's theory of quantification No. 3 and discriminant analysis, were employed in the following two steps,respectively, to simulate the procedure taken by an experienced surveyor in the field; category-class establishment based on the similarity between samples with regard to their response pattern to the soil attributes and sample allocation into established classes. Soil attributes used here were selected in reference to surveyor's field procedure. About 90 % of the samples examined were allocated by means of the numerical methods to the same class as done by the surveyor. Therefore, the procedure proposed in this study, which is the combination of soil attribute selection, Hayashi's theory of quantification No. 3 and discriminant analysis, is believed useful for classifying soil material and soil type.

Since this is a mere case study carried out in a small area, we cannot say that the procedures adopted herein are applicable everywhere to produce reasonable and reproducible classification. But we believe that the methodology or the principle underlying the used procedures are widely applicable, regardless of the area or the category at which classification is attempted.

9.2 Automated Map Compilation

Soil map and suitability map for upland crop cultivation on lowland were prepared by the use of programs implemented for COSMAS. Programs, "AUTOMAP" and "MAP," were very useful for area delineation from site data and for area retrieval from polygon data, respectively. Therefore, a map can, now, be compiled with respect to any single or multiple soil attributes which are stored as site or polygon data in the corresponding files of COSMAS.

A soil map prepared by "AUTOMAP" was satisfactory as the first approximation in automated map compilation, but it was still too crude to reproduce the actual changes in physiography. Needless to say, the more samples are available the more detailed output can be. However, the amount of labor also increases very rapidly with the number of samples. There is one way to obtain a huge amount of data with high density, speed and relatively low cost: it is remote sensing. The author expects that remotely sensed data processed by "AUTOMAP" would give much more detailed and informative output to users. As can be seen in the latest publication (Burroff and Morrison, 1980), handling of remotely sensed data is becoming more exact and precise, but only a few relationships between these data and soil characteristics are known. Future study should be directed towards elucidation of those unknown relationships, since both the hard and software already exist for collection, storage and retrieval of these data.

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Appendix I

Profile Descriptions and Analytical Data for the Representative Soils in the Mountain

1. B_B - Serpentinic material

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* PREFECTURE,COUNTY          ;  KYOTO-FU,YOZA-GUN,KAYA-CHO
* PHYSIOGRAPHIC REGION       ;  KAYA-DANI
* SURVEY                     ;NAME(  KAYA'77     )   DATE(NOV.'77 )  OBSERVER(  KOTA  )
* PROFILE NO.                ; 258
* TYPE OF PROFILE            ;      PIT
* TYPE OF DESCRIPTION        ;    DETAILED
* PARENT MATERIAL            ;      SERPENTINE
* LAND USE                   ;     GRASSLAND   -        NATURAL        -     BAMBOO GRASS
* LAND FORM                  ;    MOUNTAINOUS   -   MOUNTAIN   -      CREST
* TOPOGRAPHICAL DATA         ;  SLOPE                ASPECT               ELEVATION          WATER TABLE
                                     5 DEGREE          S24W                  670 M                  CM
* EROSION                    ;  CLASS                                       TYPE
                                   NONE TO SLIGHT
* DRAINAGE                   ;  RUNOFF               INTERNAL             SOIL DRANAGE
                                   MEDIUM               MEDIUM               SOMEWHAT EXCESSIVELY DRAINED
* TAXONOMIC UNIT,            ;     BLS  -   O   -   O   -  B

1      HA ( 2CM )    10YR 3/1 ; V.WET                        ; HIGH     ORGANIC MATTER CONTENT
                   COMPACTNESS -       LOOSE           ,    0 MM CONE PENETRATION
                   ABUNDANT  HORIZONTAL  ROOTS OF      GRASS
                   ABRUPT    SMOOTH     BOUNDARY ;

2      A1 ( 10CM )   10YR 4/4 ; WET      ;    LIGHT CLAY    ; MEDIUM   ORGANIC MATTER CONTENT
                   MODERAT. DEVELOPED,FINE      BLOCKY    STRUCTURE ,
                   FRIABLE                    , MODERAT. STICKY ,    VERY   PLASTIC
                   COMPACTNESS - DEEP FINGER-PRINT    ,   10 MM CONE PENETRATION
                   MANY      HORIZONTAL  ROOTS OF      GRASS
                   CLEAR     SMOOTH     BOUNDARY ;

3      BC ( 45CM+)   10YR 5/6 ; MOIST    ;    LIGHT CLAY    ; LOW      ORGANIC MATTER CONTENT
                   WEAKLY   DEVELOPED,V.FINE    BLOCKY    STRUCTURE ,
                   FRIABLE                    , MODERAT. STICKY ,    VERY   PLASTIC
                   COMPACTNESS - SHALLOW FINGER-PRINT ,   20 MM CONE PENETRATION
                   FEW        UBIQUITOUS ROOTS OF      GRASS
                   DOMINANT STONE - FEW      PEBBLE   MODERAT. WEATHERED, ANGULAR      SHAPED, DERIVED FROM SERPENTINE
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************CHEMICAL DATA************

HOR	PH H2O	PH KCL	EXTR.BASES K	EXTR.BASES NA	EXTR.BASES CA	EXTR.BASES MG	EXTR.BASES SUM	CEC	BASE -SAT.	TOTAL C	TOTAL N	TOTAL C/N	TOTAL P2O5	P2O5 -ABS.
			<-- MEQ/100GSOIL					-->	<-- %		-->		<-- MG/100GSOIL	-->
1.	I******	******	******	******	******	******	******	******	******	******	******	******	******	******
2.	I 4.21	3.98	0.38	0.15	0.45	0.34	1.32	22.26	5.9	5.71	0.308	18.54	101.1	*******
3.	I 4.51	4.28	0.06	0.11	0.13	0.06	0.36	12.55	2.9	1.11	0.131	3.47	28.3	734.6

HOR	AV. P2O5	AV. SIO2	FREE OXIDES MNO2	FREE OXIDES FE2O3	FREE OXIDES AL2O3
	<-MG/100GSOIL->		<-- %		-->
1.	I******	******	******	******	******
2.	I******	******	******	******	******
3.	I******	******	******	******	******

************PHYSICAL DATA************

HOR	BULK -DENS.	PART. -DENS.	H2O -CONT.	PORE	H2O -SAT.	MECHANICAL ANALYSIS C.SAND	MECHANICAL ANALYSIS F.SAND	MECHANICAL ANALYSIS SILT	MECHANICAL ANALYSIS CLAY	TEXT
			<--			%			-->	
1.	I******	******	******	******	******	******	******	******	******	***
2.	I 0.48	2.96	89.8	83.8	51.3	5.5	19.6	30.1	44.8	LIC
3.	I 1.22	2.97	39.8	59.1	81.9	12.1	27.6	26.3	33.9	LIC

2. B_B - Coarse-to-medium grained granitic material

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* PREFECTURE,COUNTY          ;  KYOTO-FU,YOZA-GUN,KAYA-CHO
* PHYSIOGRAPHIC REGION       ;  KAYA-DANI
* SURVEY                     ;NAME(  KAYA'77     )   DATE(NOV.'77 )  OBSERVER(  KOTA  )
* PROFILE NO.                ; 270
* TYPE OF PROFILE            ;       PIT
* TYPE OF DESCRIPTION        ;    DETAILED
* PARENT MATERIAL            ;         GRANITE
* LAND USE                   ;     FORESTED    -          NATURAL          -      PINE-DECIDUCUS
* LAND FORM                  ;    MOUNTAINOUS  -   MOUNTAIN    -      CREST
* TOPOGRAPHICAL DATA         ;  SLOPE                ASPECT              ELEVATION           WATER TABLE
                                     15 DEGREE          S30E                250 M                  CM
* EROSION                    ;  CLASS                                      TYPE
                                   NONE TO SLIGHT
* DRAINAGE                   ;  RUNOFF               INTERNAL            SOIL DRANAGE
                                   MEDIUM                MEDIUM              SOMEWHAT EXCESSIVELY DRAINED
* TAXONOMIC UNIT,            ;     BLS  -   O    -   O    -  B

1    A1 (  3CM )     10YR 4/4 ; MOIST    ;    SANDY LOAM    ; MEDIUM   ORGANIC MATTER CONTENT
                   WEAKLY   DEVELOPED,FINE      CRUMB     STRUCTURE ,
                   V.FRIAB.                   , NON-     STICKY , SLIGHTLY PLASTIC
                   COMPACTNESS - FINGER PENETRABLE    ,     7 MM CONE PENETRATION
                   ABUNDANT  HORIZONTAL  ROOTS OF  DECIDUOUS TREE
                   ABRUPT    SMOOTH    BOUNDARY ;

2    B1 ( 17CM )     10YR 6/8 ; MOIST    ;     CLAY LOAM    ; LOW      ORGANIC MATTER CONTENT
                   WEAKLY   DEVELOPED,FINE      CRUMB     STRUCTURE ,
                   V.FRIAB.                   , SLIGHTLY STICKY , MODERAT. PLASTIC
                   COMPACTNESS - DEEP FINGER-PRINT    ,    16 MM CONE PENETRATION
                   FEW       HORIZONTAL  ROOTS OF  DECIDUOUS TREE
                   GRADUAL   SMOOTH    BOUNDARY ;

3    B2 ( 17CM )    7.5YR 6/8 ; MOIST    ;     CLAY LOAM    ; LOW      ORGANIC MATTER CONTENT
                   WEAKLY   DEVELOPED,FINE      CRUMB     STRUCTURE ,
                   V.FRIAB.                   , SLIGHTLY STICKY , SLIGHTLY PLASTIC
                   COMPACTNESS - DEEP FINGER-PRINT    ,    17 MM CONE PENETRATION
                   FEW       HORIZONTAL  ROOTS OF  DECIDUOUS TREE
                   GRADUAL   SMOOTH    BOUNDARY ;
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4 C (30CM+) 10YR 6/8 ; MOIST ; SANDY LOAM ; LOW ORGANIC MATTER CONTENT
SNG.GRA. STRUCTURE ,
V.FRIAB. , NON- STICKY , SLIGHTLY PLASTIC
COMPACTNESS - DEEP FINGER-PRINT , 17 MM CONE PENETRATION
FEW HORIZONTAL ROOTS OF DECIDUOUS TREE

************CHEMICAL DATA************

HOR		-----PH----- H2O	KCL	---EXTR.BASES--- K	NA	CA	MG	SUM	CEC	BASE -SAT.	---TOTAL--- C	N	C/N	P2O5	P2O5 -ABS.
				<---	MEQ/100GSOIL			--->		<---	%	--->		<--MG/100GSOIL-->	
1.	I	3.89	3.49	0.40	0.09	1.03	0.36	1.88	30.38	6.2	6.09	0.311	19.58	68.7	********
2.	I	******	******	******	******	******	******	******	******	******	******	******	******	******	******
3.	I	4.52	4.01	0.23	0.14	0.38	0.67	1.42	24.02	5.9	0.56	0.048	11.67	34.8	795.8
4.	I	******	******	******	******	******	******	******	******	******	******	******	******	******	******

HOR		AV. P2O5	AV. SIO2	------FREE OXIDES------ MNO2	FE2O3	AL2O3
		<-MG/100GSOIL->		<---	%	--->
1.	I	*******	*******	*******	*******	*******
2.	I	*******	*******	*******	*******	*******
3.	I	*******	*******	*******	*******	*******
4.	I	*******	*******	*******	*******	*******

************PHYSICAL DATA************

HOR		BULK -DENS.	PART. -DENS.	H2O -CONT.	PORE	H2O -SAT.	-----MECHANICAL ANALYSIS----- C.SAND	F.SAND	SILT	CLAY	TEXT
				<---			%			--->	
1.	I	0.71	2.60	37.8	72.8	36.7	15.0	36.8	21.4	26.8	LiC
2.	I	******	******	******	******	******	******	******	******	******	***
3.	I	1.11	2.87	30.6	61.3	55.5	15.4	43.6	14.5	26.5	SC
4.	I	******	******	******	******	******	******	******	******	******	***

3. B_D - Serpentinic material

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* PREFECTURE,COUNTY        ;  KYOTO-FU,YOZA-GUN,KAYA-CHO
* PHYSIOGRAPHIC REGION     ;  KAYA-DANI
* SURVEY                   ;NAME(  KAYA'77    )  DATE(NOV.'77 )  OBSERVER(  KOTA  )
* PROFILE NO.              ;  27
* TYPE OF PROFILE          ;      PIT
* TYPE OF DESCRIPTION      ;    DETAILED
* PARENT MATERIAL          ;      SERPENTINE
* LAND USE                 ;     FORESTED    -       MANAGED        -        CEDAR
* LAND FORM                ;    MOUNTAINOUS  -   MOUNTAIN    -   FOOT SLOPE
* TOPOGRAPHICAL DATA       ;  SLOPE              ASPECT           ELEVATION         WATER TABLE
                                11 DEGREE          N30W              480 M                  CM
* EROSION                  ;  CLASS                                TYPE
                                NONE TO SLIGHT
* DRAINAGE                 ;  RUNOFF             INTERNAL          SOIL DRANAGE
                                MEDIUM               SLOW                  MODERATELY     DRAINED
* TAXONOMIC UNIT,          ;     BFS  -   O   -   O   -  D

1      A1 ( 18CM )    7.5YR 2/2 ; WET      ;   LIGHT CLAY    ; HIGH    ORGANIC MATTER CONTENT
                    MODERAT. DEVELOPED,MEDIUM    BLOCKY     STRUCTURE , BREAKES TO WEAKLY   DEVELOPED FINE    CRUMB    STRUCTURE )
                    FRIABLE (SL.HARD WHEN DRY) , MODERAT. STICKY ,  VERY    PLASTIC
                    COMPACTNESS - FINGER PENETRABLE     ,   17 MM CONE PENETRATION
                    PROFUSE  MEDIUM   PORE ; MANY     UBIQUITOUS  ROOTS OF      GRASS
                    DOMINANT STONE - FEW      PEBBLE   MODERAT. WEATHERED, ROUND         SHAPED, DERIVED FROM SERPENTINE
                      SHARP   SMOOTH    BOUNDARY ;

2      B1 (  4CM )     10YR 3/3 ; WET       ;   LIGHT CLAY    ; MEDIUM   ORGANIC MATTER CONTENT
                    MASSIV   STRUCTURE ,
                    FRIABLE (SL.HARD WHEN DRY) , MODERAT. STICKY ,   VERY   PLASTIC
                    COMPACTNESS - DEEP FINGER-PRINT     ,  24 MM CONE PENETRATION
                    FEW      MEDIUM   PORE ; FEW      HORIZONTAL  ROOTS OF EVER-GREEN TREE
                    DISTINCT  SMOOTH    BOUNDARY ;

3   II A1 ( 24CM )     10YR 3/2 ; WET       ;   LIGHT CLAY    ; MEDIUM   ORGANIC MATTER CONTENT
                    WEAKLY   DEVELOPED,FINE     BLOCKY     STRUCTURE ,
                    V.FRIAB.(SL.HARD WHEN DRY) , MODERAT. STICKY ,   VERY   PLASTIC
                    COMPACTNESS - DEEP FINGER-PRINT     ,  25 MM CONE PENETRATION
                    MANY     MEDIUM   PORE ; MANY     HORIZONTAL  ROOTS OF EVER-GREEN TREE
                    DOMINANT STONE - FEW      PEBBLE   MODERAT. WEATHERED, ROUND         SHAPED, DERIVED FROM SERPENTINE
                      SHARP   SMOOTH    BOUNDARY ;
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4   II A3 (  8CM )     7.5YR 4/4 ; WET       ;    LIGHT CLAY     ; MEDIUM    ORGANIC MATTER CONTENT
                     WEAKLY    DEVELOPED,FINE       BLOCKY     STRUCTURE ,
                     V.FRIAB.(SL.HARD WHEN DRY) , MODERAT. STICKY ,    VERY   PLASTIC
                     COMPACTNESS - SHALLOW FINGER-PRINT ,    23 MM CONE PENETRATION
                     FEW      MEDIUM    PORE ; FEW        HORIZONTAL  ROOTS OF EVER-GREEN TREE
                     DISTINCT  SMOOTH     BOUNDARY ;

5   II B1 ( 40CM+)     7.5YR 5/6 ; WET       ;     HEAVY CLAY     ; LOW      ORGANIC MATTER CONTENT
                     WEAKLY    DEVELOPED,FINE       BLOCKY     STRUCTURE ,
                     FIRM    (HARD     WHEN DRY) ,    VERY   STICKY ,    VERY   PLASTIC
                     COMPACTNESS - SHALLOW FINGER-PRINT ,    20 MM CONE PENETRATION
                     FEW      MEDIUM    PORE ; FEW        HORIZONTAL  ROOTS OF EVER-GREEN TREE
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************CHEMICAL DATA************

HOR	-----PH----- H2O	KCL	-----EXTR.BASES----- K	NA	CA	MG	SUM	CEC	BASE -SAT.	-----TOTAL----- C	N	C/N	P2O5	P2O5 -ABS.
			<----MEQ/100GSOIL					---->	<----%----		---->		<--MG/100GSOIL-->	
1.	I**************		0.48	0.18	0.42	0.57	1.65	**********	**********	**********	**********	**********	**********	**********
2.	I**************		0.20	0.10	0.11	0.07	0.48	**********	**********	**********	**********	**********	**********	**********
3.	I**************		0.21	0.08	0.09	0.07	0.45	**********	**********	**********	**********	**********	**********	**********
4.	I**************		0.16	0.08	0.34	0.14	0.72	**********	**********	**********	**********	**********	**********	**********
5.	I**************		0.18	0.13	0.10	0.27	0.68	**********	**********	**********	**********	**********	**********	**********

HOR	AV. P2O5	AV. SIO2	------FREE OXIDES------ MNO2	FE2O3	AL2O3
	<-MG/100GSOIL->		<-----%-----		----->
1.	I****************		************************		
2.	I****************		************************		
3.	I****************		************************		
4.	I****************		************************		
5.	I****************		************************		

************PHYSICAL DATA************

HOR	BULK -DENS.	PART. -DENS.	H2O -CONT.	PORE	H2O -SAT.	-----MECHANICAL ANALYSIS----- C.SAND	F.SAND	SILT	CLAY	TEXT
			<------------		------%	------------			------>	
1.	I 0.40	2.29	111.5	82.5	54.0	**********	**********	**********	**********	***
2.	I**********	**********	**********	**********	**********	**********	**********	**********	**********	***
3.	I 0.63	2.49	93.9	74.5	80.0	**********	**********	**********	**********	***
4.	I**********	**********	**********	**********	**********	**********	**********	**********	**********	***
5.	I 0.95	2.60	58.3	63.4	87.0	**********	**********	**********	**********	***

4. B_D - Fine grained granitic material

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* PREFECTURE,COUNTY          ;  KYOTO-FU,YOZA-GUN,KAYA-CHO
* PHYSIOGRAPHIC REGION       ;  KAYA-DANI
* SURVEY                     ;NAME(   KAYA'77      )    DATE(NOV.'77 )   OBSERVER(  KOTA  )
* PROFILE NO.                ;  34
* TYPE OF PROFILE            ;       PIT
* TYPE OF DESCRIPTION        ;     DETAILED
* PARENT MATERIAL            ;         GRANITE
* LAND USE                   ;      FORESTED     -          NATURAL            -       PINE-DECIDUOUS
* LAND FORM                  ;     MOUNTAINOUS   -     MOUNTAIN     -    FOOT SLOPE
* TOPOGRAPHICAL DATA         ;  SLOPE                  ASPECT              ELEVATION            WATER TABLE
                                   12 DEGREE              S80W                 215 M                     CM
* EROSION                    ;  CLASS                                         TYPE
                                  NONE TO SLIGHT
* DRAINAGE                   ;  RUNOFF                 INTERNAL             SOIL DRANAGE
                                     RAPID                   RAPID             SOMEWHAT EXCESSIVELY DRAINED
* TAXONOMIC UNIT,            ;     BFS   -    O    -    O    -  D

1     A1 ( 14CM )     10YR 3/3 ; MOIST     ;     CLAY LOAM     ; MEDIUM   ORGANIC MATTER CONTENT
                    WEAKLY   DEVELOPED,FINE      CRUMB      STRUCTURE ,
                    V.FRIAB.(SOFT    WHEN DRY) , SLIGHTLY STICKY , MODERAT. PLASTIC
                    COMPACTNESS - FINGER PENETRABLE     ,  12 MM CONE PENETRATION
                    MANY     COARSE    PORE ; MANY      HORIZONTAL  ROOTS OF EVER-GREEN TREE
                    DOMINANT STONE - MANY     GRAVEL    MODERAT. WEATHERED, ROUND           SHAPED, DERIVED FROM GRANITE(FINE)
                      SHARP    SMOOTH     BOUNDARY ;

2     A1 ( 15CM )     10YR 4/3 ; WET       ;     CLAY LOAM     ; MEDIUM   ORGANIC MATTER CONTENT
                    WEAKLY   DEVELOPED,FINE      CRUMB      STRUCTURE ,
                    V.FRIAB.(SOFT    WHEN DRY) , MODERAT. STICKY , MODERAT. PLASTIC
                    COMPACTNESS - FINGER PENETRABLE     ,  16 MM CONE PENETRATION
                    MANY     COARSE    PORE ; FEW       UBIQUITOUS  ROOTS OF EVER-GREEN TREE
                    DOMINANT STONE - MANY     PEBBLE    MODERAT. WEATHERED, ROUND           SHAPED, DERIVED FROM GRANITE(FINE)
                    DISTINCT  SMOOTH     BOUNDARY ;

3     A3 ( 22CM )     7.5YR 4/3 ; WET      ;     CLAY LOAM     ; MEDIUM   ORGANIC MATTER CONTENT
                    WEAKLY   DEVELOPED,FINE      GRANULAR   STRUCTURE ,
                    FRIABLE (SOFT    WHEN DRY) , MODERAT. STICKY , MODERAT. PLASTIC
                    COMPACTNESS - DEEP FINGER-PRINT     ,  16 MM CONE PENETRATION
                    MANY     MEDIUM    PORE ; FEW       UBIQUITOUS  ROOTS OF EVER-GREEN TREE
                    DOMINANT STONE - MANY     PEBBLE    MODERAT. WEATHERED, ROUND           SHAPED, DERIVED FROM GRANITE(FINE)
                    DISTINCT  IRREGUL.   BOUNDARY ;
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4 B2 (30CM+) 10YR 5/4 ; WET ; CLAY LOAM ; LOW ORGANIC MATTER CONTENT
WEAKLY DEVELOPED,FINE BLOCKY STRUCTURE ,
FRIABLE (SOFT WHEN DRY) , MODERAT. STICKY , MODERAT. PLASTIC
COMPACTNESS - SHALLOW FINGER-PRINT , 19 MM CONE PENETRATION
FEW MEDIUM PORE ; FEW UBIQUITOUS ROOTS OF EVER-GREEN TREE
DOMINANT STONE - FEW PEBBLE MODERAT. WEATHERED, ROUND SHAPED, DERIVED FROM GRANITE(FINE)

************CHEMICAL DATA************

HOR		PH H2O	PH KCL	EXTR.BASES K	EXTR.BASES NA	EXTR.BASES CA	EXTR.BASES MG	EXTR.BASES SUM	CEC	BASE -SAT.	TOTAL C	TOTAL N	TOTAL C/N	TOTAL P2O5	P2O5 -ABS.
				<---		MEQ/100GSOIL			--->	<---	%	--->	<---	MG/100GSOIL	--->
1.	I	4.65	3.88	0.17	0.18	1.16	0.36	1.87	22.00	8.5	4.60	******	******	******	******
2.	I	******	******	******	******	******	******	******	******	******	******	******	******	******	******
3.	I	******	******	******	******	******	******	******	******	******	******	******	******	******	******
4.	I	5.00	4.20	0.07	0.10	0.10	0.01	0.28	12.36	2.3	1.32	******	******	******	******

HOR		AV. P2O5	AV. SIO2	FREE OXIDES MNO2	FREE OXIDES FE2O3	FREE OXIDES AL2O3
		<-MG/100GSOIL->		<---	%	--->
1.	I	********	********	********	********	********
2.	I	********	********	********	********	********
3.	I	********	********	********	********	********
4.	I	********	********	********	********	********

************PHYSICAL DATA************

HOR		BULK -DENS.	PART. -DENS.	H2O -CONT.	PORE	H2O -SAT.	MECHANICAL ANALYSIS C.SAND	MECHANICAL ANALYSIS F.SAND	MECHANICAL ANALYSIS SILT	MECHANICAL ANALYSIS CLAY	TEXT
				<---		%				--->	
1.	I	0.54	2.58	39.1	79.2	27.0	21.8	33.7	18.6	25.9	LiC
2.	I	0.95	2.59	33.1	63.2	50.0	******	******	******	******	***
3.	I	1.09	2.69	36.1	64.1	54.0	******	******	******	******	***
4.	I	1.46	2.60	34.3	58.1	64.0	21.8	34.1	18.0	26.2	LiC

5. $B_{D(d)}$ - Serpentinic material

* PREFECTURE,COUNTY ; KYOTO-FU,YOZA-GUN,KAYA-CHO

* PHYSIOGRAPHIC REGION ; KAYA-DANI

* SURVEY ;NAME(KAYA'77) DATE(NOV.'77) OBSERVER(KOTA)

* PROFILE NO. ; 29

* TYPE OF PROFILE ; PIT

* TYPE OF DESCRIPTION ; DETAILED

* PARENT MATERIAL ; SERPENTINE

* LAND USE ; FORESTED - NATURAL - PINE-DECIDUOUS

* LAND FORM ; MOUNTAINOUS - MOUNTAIN - HILL SLOPE

* TOPOGRAPHICAL DATA ; SLOPE 20 DEGREE ; ASPECT S75W ; ELEVATION 574 M ; WATER TABLE CM

* EROSION ; CLASS NONE TO SLIGHT ; TYPE

* DRAINAGE ; RUNOFF RAPID ; INTERNAL SLOW ; SOIL.DRANAGE MODERATELY DRAINED

* TAXONOMIC UNIT, ; BFS - 0 - 0 - D(D)

1 A1 (5CM) 10YR 3/2 ; WET ; LIGHT CLAY ; MEDIUM ORGANIC MATTER CONTENT
MODERAT. DEVELOPED,COARSE CRUMB STRUCTURE ,
FRIABLE (SL.HARD WHEN DRY) , MODERAT. STICKY , VERY PLASTIC
COMPACTNESS - FINGER PENETRABLE , 16 MM CONE PENETRATION
MANY COARSE PORE ; MANY UBIQUITOUS ROOTS OF GRASS
DOMINANT STONE - FEW PEBBLE SLIGHTLY WEATHERED, ROUND SHAPED, DERIVED FROM SERPENTINE
SHARP WAVY BOUNDARY ;

2 A3 (9CM) 10YR 4/4 ; WET ; HEAVY CLAY ; MEDIUM ORGANIC MATTER CONTENT
MODERAT. DEVELOPED,FINE BLOCKY STRUCTURE ,
MANY FINE FAINT CUTAN (10YR 4/3)
FRIABLE (HARD WHEN DRY) , VERY STICKY , VERY PLASTIC
COMPACTNESS - FINGER PENETRABLE , 16 MM CONE PENETRATION
MANY COARSE PORE ; MANY UBIQUITOUS ROOTS OF GRASS
DOMINANT STONE - FEW PEBBLE MODERAT. WEATHERED, ROUND SHAPED, DERIVED FROM SERPENTINE
SHARP WAVY BOUNDARY ;

3 II A1 (10CM) 10YR 4/3 ; WET ; HEAVY CLAY ; MEDIUM ORGANIC MATTER CONTENT
MODERAT. DEVELOPED,MEDIUM BLOCKY STRUCTURE ,
MANY FINE FAINT CUTAN (10YR 4/3)
FRIABLE (HARD WHEN DRY) , VERY STICKY , VERY PLASTIC
COMPACTNESS - DEEP FINGER-PRINT , 20 MM CONE PENETRATION
FEW FINE PORE ; MANY UBIQUITOUS ROOTS OF DECIDUOUS TREE
DOMINANT STONE - MANY PEBBLE MODERAT. WEATHERED, ROUND SHAPED, DERIVED FROM SERPENTINE
DISTINCT SMOOTH BOUNDARY ;

4 II B1 (5CM) 10YR 4/6 ; WET ; HEAVY CLAY ; MEDIUM ORGANIC MATTER CONTENT
WEAKLY DEVELOPED, FINE BLOCKY STRUCTURE ,
FIRM (HARD WHEN DRY) , VERY STICKY , VERY PLASTIC
COMPACTNESS - SHALLOW FINGER-PRINT , 20 MM CONE PENETRATION
FEW FINE PORE ; FEW UBIQUITOUS ROOTS OF DECIDUOUS TREE
DOMINANT STONE - FEW PEBBLE MODERAT. WEATHERED, ROUND SHAPED, DERIVED FROM SERPENTINE
DIFFUSE SMOOTH BOUNDARY ;

5 II B2 (40CM) 7.5YR 5/6 ; WET ; HEAVY CLAY ; LOW ORGANIC MATTER CONTENT
FRIABLE (HARD WHEN DRY) , VERY STICKY , VERY PLASTIC
COMPACTNESS - DEEP FINGER-PRINT , 19 MM CONE PENETRATION
MANY FINE PORE ; FEW UBIQUITOUS ROOTS OF DECIDUOUS TREE
DOMINANT STONE - FEW PEBBLE MODERAT. WEATHERED, ROUND SHAPED, DERIVED FROM SERPENTINE
DIFFUSE BOUNDARY ;

************CHEMICAL DATA************

HOR	-----PH----- H2O	KCL	------------EXTR.BASES------------ K	NA	CA	MG	SUM	CEC	BASE -SAT.	-----------TOTAL----------- C	N	C/N	P2O5	P2O5 -ABS.
			<-------------MEQ/100GSOIL------------->						<---------%--------->				<--MG/100GSOIL-->
1.	I**************		0.69	0.11	5.40	5.55	11.75	**						
2.	I**************		0.36	0.13	2.41	7.16	10.06	**						
3.	I**************		0.42	0.14	1.81	5.27	7.64	**						
4.	I**************		0.59	0.15	0.92	4.69	6.35	**						
5.	I**************		0.58	0.17	0.72	4.44	5.91	**						

HOR	AV. P2O5	AV. SIO2	------FREE OXIDES------ MNO2	FE2O3	AL2O3
	<-MG/100GSOIL->		<----------%---------->		
1.	I****************		***********************		
2.	I****************		***********************		
3.	I****************		***********************		
4.	I****************		***********************		
5.	I****************		***********************		

***********PHYSICAL DATA***********

HOR	BULK -DENS.	PART. -DENS.	H2O -CONT.	PORE	H2O -SAT.	-----MECHANICAL ANALYSIS----- C.SAND	F.SAND	SILT	CLAY	TEXT
			<-------------------------%------------------------>							
1.	I 0.85	2.58	53.1	67.0	67.0	*********************************				***
2.	I**									***
3.	I 1.09	2.63	44.4	58.6	82.0	*********************************				***
4.	I**									***
5.	I 1.07	2.65	50.3	59.7	90.0	*********************************				***

6. $B_{D(d)}$ - Mixed material of serpentine and granite

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* PREFECTURE,COUNTY          ;  KYOTO-FU,YOZA-GUN,KAYA-CHO
* PHYSIOGRAPHIC REGION       ;  KAYA-DANI
* SURVEY                     ;NAME(   KAYA'77     )   DATE(NOV.'77 )   OBSERVER(  KOTA  )
* PROFILE NO.                ;  65
* TYPE OF PROFILE            ;      PIT
* TYPE OF DESCRIPTION        ;    DETAILED
* PARENT MATERIAL            ;     GRANITE(FINE)
* LAND USE                   ;     FORESTED    -        NATURAL         -  DECIDUOUS BROADLEAVES
* LAND FORM                  ;    MOUNTAINOUS  -   MOUNTAIN   -    HILL SLOPE
* TOPOGRAPHICAL DATA         ;  SLOPE              ASPECT            ELEVATION          WATER TABLE
                                   20 DEGREE         N35W               350 M                 CM
* EROSION                    ;  CLASS                                 TYPE
                                  NONE TO SLIGHT
* DRAINAGE                   ;  RUNOFF             INTERNAL          SOIL DRANAGE
                                    MEDIUM              RAPID                    WELL        DRAINED
* TAXONOMIC UNIT,            ;     BFS  -   0   -   0   -  D(D)

1    A1 ( 20CM )     10YR 3/3 ; MOIST     ;      CLAY LOAM     ; MEDIUM   ORGANIC MATTER CONTENT
                 WEAKLY   DEVELOPED,FINE         BLOCKY     STRUCTURE ,
                 FRIABLE (SL.HARD WHEN DRY) , SLIGHTLY STICKY , MODERAT. PLASTIC
                 COMPACTNESS - DEEP FINGER-PRINT      ,   13 MM CONE PENETRATION
                 MANY     MEDIUM    PORE ; ABUNDANT  UBIQUITOUS  ROOTS OF      GRASS
                 DISTINCT  SMOOTH    BOUNDARY ;

2    A3 ( 15CM )     10YR 4/3 ; WET       ;      SILT LOAM     ; MEDIUM   ORGANIC MATTER CONTENT
                 MODERAT. DEVELOPED,FINE         BLOCKY     STRUCTURE ,
                 FRIABLE (SL.HARD WHEN DRY) , SLIGHTLY STICKY , SLIGHTLY PLASTIC
                 COMPACTNESS - DEEP FINGER-PRINT      ,   13 MM CONE PENETRATION
                 FEW      MEDIUM    PORE ; MANY      HORIZONTAL  ROOTS OF  DECIDUOUS TREE
                 DOMINANT STONE - MANY     PEBBLE    SLIGHTLY WEATHERED, ROUND        SHAPED, DERIVED FROM SERPENTINE
                   SHARP     WAVY      BOUNDARY ;

3    B1 ( 17CM )     10YR 5/4 ; WET       ;      CLAY LOAM     ;  LOW     ORGANIC MATTER CONTENT
                 WEAKLY   DEVELOPED,FINE         BLOCKY     STRUCTURE ,
                 FRIABLE (SL.HARD WHEN DRY) , SLIGHTLY STICKY , MODERAT. PLASTIC
                 COMPACTNESS - DEEP FINGER-PRINT      ,   14 MM CONE PENETRATION
                 FEW      MEDIUM    PORE ; MANY      VERTICAL    ROOTS OF  DECIDUOUS TREE
                 DOMINANT STONE - ABUNDANT COBBLE    SLIGHTLY WEATHERED, ROUND        SHAPED, DERIVED FROM GRANITE(FINE)
                 DIFFUSE   SMOOTH    BOUNDARY ;
```

B2 (25CM+) 10YR 6/6 ; WET ; CLAY LOAM ; LOW ORGANIC MATTER CONTENT
WEAKLY DEVELOPED, V.FINE NUTY STRUCTURE ,
FRIABLE (SL.HARD WHEN DRY) , SLIGHTLY STICKY , MODERAT. PLASTIC
COMPACTNESS - DEEP FINGER-PRINT , 17 MM CONE PENETRATION
MANY FINE PORE ; FEW HORIZONTAL ROOTS OF DECIDUOUS TREE

************CHEMICAL DATA************

HOR		-----PH-----		------------EXTR.BASES-----------						BASE	-----------TOTAL-----------				P2O5
		H2O	KCL	K	NA	CA	MG	SUM	CEC	-SAT.	C	N	C/N	P2O5	-ABS.
				<------------	------	MEQ/100GSOIL	------	------	------------>	<--------	%-------->			<--MG/100GSOIL-->	
1.	I	4.90	3.71	0.32	0.18	0.94	0.74	2.18	21.64	10.1	5.19	********	********	********	********
2.	I	********	********	********	********	********	********	********	********	********	********	********	********	********	********
3.	I	********	********	********	********	********	********	********	********	********	********	********	********	********	********
4.	I	5.10	4.09	0.06	0.17	0.06	0.17	0.46	10.43	4.4	0.56	********	********	********	********

HOR		AV.	AV.	------FREE OXIDES------		
		P2O5	SIO2	MNO2	FE2O3	AL2O3
		<-MG/100GSOIL->		<----------	%----------	>
1.	I	********	********	********	********	********
2.	I	********	********	********	********	********
3.	I	********	********	********	********	********
4.	I	********	********	********	********	********

************PHYSICAL DATA************

HOR		BULK	PART.	H2O		H2O	-----MECHANICAL ANALYSIS-----				
		-DENS.	-DENS.	-CONT.	PORE	-SAT.	C.SAND	F.SAND	SILT	CLAY	TEXT
				<------------	------------	------------%	------------	------------	------------	------------>	
1.	I	0.38	2.56	63.3	85.1	30.7	********	********	********	********	***
2.	I	********	********	********	********	********	********	********	********	********	***
3.	I	********	********	********	********	********	********	********	********	********	***
4.	I	0.96	3.31	49.7	70.9	67.6	********	********	********	********	***

7. $B_{D(d)}$ - Fine grained granitic material

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* PREFECTURE,COUNTY          ;  KYOTO-FU,YOZA-GUN,KAYA-CHO
* PHYSIOGRAPHIC REGION       ;  KAYA-DANI
* SURVEY                     ;NAME(  KAYA'77    )   DATE(NOV.'77 )   OBSERVER(  KOTA  )
* PROFILE NO.                ;  51
* TYPE OF PROFILE            ;     PIT
* TYPE OF DESCRIPTION        ;   DETAILED
* PARENT MATERIAL            ;    GRANITE(FINE)
* LAND USE                   ;    FORESTED   -       MANAGED       -        CEDAR
* LAND FORM                  ;   MOUNTAINOUS  -  MOUNTAIN   -  FOOT SLOPE
* TOPOGRAPHICAL DATA         ;  SLOPE             ASPECT          ELEVATION        WATER TABLE
                                   16 DEGREE        N30W              150 M                CM
* EROSION                    ;  CLASS                             TYPE
                                  NONE TO SLIGHT
* DRAINAGE                   ;  RUNOFF            INTERNAL        SOIL DRANAGE
                                   RAPID              RAPID                WELL       DRAINED
* TAXONOMIC UNIT,            ;   BFS  -  0   -  0   -  D(D)

1     A1 (  7CM )     10YR 3/4 ; MOIST   ;     LOAM      ; HIGH    ORGANIC MATTER CONTENT
                    WEAKLY   DEVELOPED,FINE     CRUMB    STRUCTURE ,
                    FRIABLE (SOFT   WHEN DRY) , SLIGHTLY STICKY , MODERAT. PLASTIC
                    COMPACTNESS - FINGER PENETRABLE    ,    6 MM CONE PENETRATION
                    MANY     COARSE   PORE ; MANY      UBIQUITOUS  ROOTS OF     GRASS
                      SHARP    SMOOTH    BOUNDARY ;

2     A1 ( 10CM )     10YR 4/4 ; MOIST   ;    CLAY LOAM    ; MEDIUM   ORGANIC MATTER CONTENT
                    WEAKLY   DEVELOPED,FINE     BLOCKY    STRUCTURE ,
                    FRIABLE (SL.HARD WHEN DRY) , MODERAT. STICKY , MODERAT. PLASTIC
                    COMPACTNESS - DEEP FINGER-PRINT    ,   15 MM CONE PENETRATION
                    MANY     MEDIUM    PORE ; MANY      HORIZONTAL  ROOTS OF     GRASS
                    DIFFUSE   SMOOTH    BOUNDARY ;

3     A3 ( 30CM )     10YR 4/4 ; WET     ;    CLAY LOAM    ;  LOW     ORGANIC MATTER CONTENT
                    WEAKLY   DEVELOPED,MEDIUM    BLOCKY    STRUCTURE ,
                    V.FRIAB.(SOFT   WHEN DRY) , MODERAT. STICKY , MODERAT. PLASTIC
                    COMPACTNESS - DEEP FINGER-PRINT    ,   14 MM CONE PENETRATION
                    MANY     MEDIUM    PORE ; FEW       HORIZONTAL  ROOTS OF EVER-GREEN TREE
                    DOMINANT STONE - FEW      GRAVEL     VERY   WEATHERED, ANGULAR     SHAPED, DERIVED FROM GRANITE(FINE)
                    DISTINCT   WAVY     BOUNDARY ;
```

4 P2 (20CM+) 10YR 5/8 ; WET ; CLAY LOAM ; LOW ORGANIC MATTER CONTENT
WEAKLY DEVELOPED,FINE BLOCKY STRUCTURE ,
FIRM (SL.HARD WHEN DRY) , MODERAT. STICKY , MODERAT. PLASTIC
COMPACTNESS - DEEP FINGER-PRINT , 19 MM CONE PENETRATION
MANY MEDIUM PORE ; FEW OBLIQUE ROOTS OF EVER-GREEN TREE
DOMINANT STONE - FEW GRAVEL VERY WEATHERED, ANGULAR SHAPED, DERIVED FROM GRANITE(FINE)

************CHEMICAL DATA************

HOR		PH H2O	PH KCL	EXTR.BASES K	EXTR.BASES NA	EXTR.BASES CA	EXTR.BASES MG	EXTR.BASES SUM	CEC	BASE -SAT.	TOTAL C	TOTAL N	TOTAL C/N	TOTAL P2O5	P2O5 -ABS.
				<-	MEQ/100GSOIL				->	<-	%	->		<--	MG/100GSOIL -->
1.	I	5.03	4.01	0.52	0.12	2.40	1.16	4.20	20.38	20.6	4.71	***	***	***	***
2.	I	***	***	***	***	***	***	***	***	***	***	***	***	***	***
3.	I	***	***	***	***	***	***	***	***	***	***	***	***	***	***
4.	I	5.13	4.06	0.45	0.14	0.17	0.08	0.84	12.91	6.5	0.55	***	***	***	***

HOR		AV. P2O5	AV. SIO2	FREE OXIDES MNO2	FREE OXIDES FE2O3	FREE OXIDES AL2O3
		<-MG/100GSOIL->		<-	%	->
1.	I	***	***	***	***	***
2.	I	***	***	***	***	***
3.	I	***	***	***	***	***
4.	I	***	***	***	***	***

************PHYSICAL DATA************

HOR		BULK -DENS.	PART. -DENS.	H2O -CONT.	PORE	H2O -SAT.	MECHANICAL ANALYSIS C.SAND	MECHANICAL ANALYSIS F.SAND	MECHANICAL ANALYSIS SILT	MECHANICAL ANALYSIS CLAY	TEXT
				<-			%			->	
1.	I	0.64	2.52	50.0	74.8	43.0	26.9	26.2	16.0	30.9	LiC
2.	I	***	***	***	***	***	***	***	***	***	***
3.	I	1.05	2.64	37.1	60.4	64.0	***	***	***	***	***
4.	I	1.21	2.66	31.7	54.7	70.0	30.4	28.7	16.2	24.7	SCL

8. $B_{D(d)}$ - Coarse-to-medium grained granitic material

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* PREFECTURE,COUNTY         ;  KYOTO-FU,YOZA-GUN,KAYA-CHO
* PHYSIOGRAPHIC REGION      ;  KAYA-DANI
* SURVEY                    ;NAME(  KAYA'77     )   DATE(NOV.'77 )  OBSERVER(  KOTA  )
* PROFILE NO.               ; 273
* TYPE OF PROFILE           ;      PIT
* TYPE OF DESCRIPTION       ;    DETAILED
* PARENT MATERIAL           ;        GRANITE
* LAND USE                  ;     FORESTED    -        MANAGED       -        CYPRESS
* LAND FORM                 ;    MOUNTAINOUS  -    MOUNTAIN    -    FOOTSLOPE
* TOPOGRAPHICAL DATA        ;  SLOPE                ASPECT           ELEVATION         WATER TABLE
                                 37 DEGREE            N90W              190 M                 CM
* EROSION                   ;  CLASS                                  TYPE
                                 NONE TO SLIGHT
* DRAINAGE                  ;  RUNOFF               INTERNAL          SOIL DRANAGE
                                 V.RAPID               MEDIUM             SOMEWHAT EXCESSIVELY DRAINED
* TAXONOMIC UNIT,           ;     BLS  -   0   -   0   -  D(D)

1    A1 (  4CM )    10YR 3/3 ; WET      ;    CLAY LOAM    ; MEDIUM   ORGANIC MATTER CONTENT
                  WEAKLY   DEVELOPED,FINE     CRUMB     STRUCTURE ,
                  V.FRIAB.                  , SLIGHTLY STICKY , SLIGHTLY PLASTIC
                  COMPACTNESS - FINGER PENETRABLE    ,    7 MM CONE PENETRATION
                  MANY      UBIQUITOUS ROOTS OF     GRASS
                  ABRUPT    SMOOTH     BOUNDARY ;

2    A3 ( 16CM )    10YR 4/3 ; MOIST    ;    CLAY LOAM    ; LOW      ORGANIC MATTER CONTENT
                  WEAKLY   DEVELOPED,FINE     CRUMB     STRUCTURE ,
                  V.FRIAB.                  , SLIGHTLY STICKY , SLIGHTLY PLASTIC
                  COMPACTNESS - FINGER PENETRABLE    ,    8 MM CONE PENETRATION
                  MANY      UBIQUITOUS ROOTS OF  DECIDUOUS TREE
                  DOMINANT STONE - MANY     GRAVEL    MODERAT. WEATHERED, SUBANGULAR   SHAPED, DERIVED FROM GRANITE(FINE)
                  CLEAR     SMOOTH     BOUNDARY ;

3    B1 ( 15CM )    10YR 5/4 ; MOIST    ;  SANDY CLAY LOAM ; LOW     ORGANIC MATTER CONTENT
                  WEAKLY   DEVELOPED,FINE     CRUMB     STRUCTURE ,
                  V.FRIAB.                  , SLIGHTLY STICKY , SLIGHTLY PLASTIC
                  COMPACTNESS - FINGER PENETRABLE    ,   10 MM CONE PENETRATION
                  FEW      HORIZONTAL  ROOTS OF  DECIDUOUS TREE
                  DOMINANT STONE - FEW      S.PEBBLE    VERY    WEATHERED, ANGULAR     SHAPED, DERIVED FROM GRANITE(FINE)
                  CLEAR     SMOOTH     BOUNDARY ;
```

4 B2 (25CM+) 10YR 5/6 ; SANDY LOAM ; LOW ORGANIC MATTER CONTENT
WEAKLY DEVELOPED, FINE CRUMB STRUCTURE ,
V.FRIAB. , NON- STICKY , SLIGHTLY PLASTIC
COMPACTNESS - FINGER PENETRABLE , 11 MM CONE PENETRATION
FEW HORIZONTAL ROOTS OF DECIDUOUS TREE
DOMINANT STONE - MANY PEBBLE VERY WEATHERED, SUBANGULAR SHAPED, DERIVED FROM GRANITE(FINE)

************CHEMICAL DATA************

HOR	PH H2O	PH KCL	EXTR.BASES K	NA	CA	MG	SUM	CEC	BASE -SAT.	TOTAL C	N	C/N	P2O5	P2O5 -ABS.
			<-------------MEQ/100GSOIL					------------->		<---------%--------->				<--MG/100GSOIL-->
1.	I******													
2.	4.95	4.09	0.14	0.13	2.88	1.51	4.66	15.15	30.8	1.99	0.183	10.87	49.3	765.2
3.	5.02	4.14	0.11	0.18	2.40	1.56	4.25	23.02	18.5	0.62	0.068	9.12	34.0	979.4
4.	I******													

HOR	AV. P2O5	AV. SIO2	FREE OXIDES MNO2	FE2O3	AL2O3
	<-MG/100GSOIL->		<----------%---------->		
1.	I****************		************************		
2.	I****************		************************		
3.	I****************		************************		
4.	I****************		************************		

************PHYSICAL DATA************

HOR	BULK -DENS.	PART. -DENS.	H2O -CONT.	PORE	H2O -SAT.	MECHANICAL ANALYSIS C.SAND	F.SAND	SILT	CLAY	TEXT
			<------------------------			%			------------------------>	
1.	I******									***
2.	0.81	2.85	28.4	71.4	32.4	39.8	33.0	12.1	15.2	SCL
3.	1.19	2.85	25.5	58.2	52.2	35.3	37.6	14.1	13.0	SL
4.	I******									***

9. B_F - Corse-to-medium grained granitic material

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* PREFECTURE,COUNTY          ;  KYOTO-FU,YOZA-GUN,KAYA-CHO

* PHYSIOGRAPHIC REGION       ;  KAYA-DANI

* SURVEY                     ;NAME(  KAYA'77     )   DATE(NOV.'77 )   OBSERVER(  KOTA  )

* PROFILE NO.                ; 272

* TYPE OF PROFILE            ;      PIT

* TYPE OF DESCRIPTION        ;    DETAILED

* PARENT MATERIAL            ;         GRANITE

* LAND USE                   ;     FORESTED    -          MANAGED           -            CEDAR

* LAND FORM                  ;    MOUNTAINOUS   -    MOUNTAIN    -     FOOTSLOPE

* TOPOGRAPHICAL DATA         ;  SLOPE                 ASPECT              ELEVATION             WATER TABLE
                                     15 DEGREE          N05E                 220 M                      CM

* EROSION                    ;  CLASS                                       TYPE
                                   NONE TO SLIGHT

* DRAINAGE                   ;  RUNOFF                INTERNAL            SOIL DRANAGE
                                    SLOW                 MEDIUM                  MODERATELY        DRAINED

* TAXONOMIC UNIT,            ;     BLS  -   O    -   O    -  F

1      A1 ( 15CM )     10YR 3/4 ; WET      ;     CLAY LOAM     ; LOW      ORGANIC MATTER CONTENT
                    WEAKLY   DEVELOPED,FINE      CRUMB     STRUCTURE ,
                    FRIABLE                    , SLIGHTLY STICKY , SLIGHTLY PLASTIC
                    COMPACTNESS - DEEP FINGER-PRINT     ,    16 MM CONE PENETRATION
                    ABUNDANT  HORIZONTAL  ROOTS OF  DECIDUOUS TREE
                    CLEAR     WAVY      BOUNDARY ;

2      B2 ( 25CM )     10YR 5/4 ; WET      ;  SANDY CLAY LOAM ; LOW      ORGANIC MATTER CONTENT
                    WEAKLY   DEVELOPED,FINE      CRUMB     STRUCTURE ,
                    FEW      COARSE   FAINT    MOTTLE (   10YR 5/2)
                    FRIABLE                    , SLIGHTLY STICKY , SLIGHTLY PLASTIC
                    COMPACTNESS - DEEP FINGER-PRINT     ,    13 MM CONE PENETRATION
                    FEW       HORIZONTAL  ROOTS OF  DECIDUOUS TREE
                    CLEAR     SMOOTH    BOUNDARY ;

3      C  ( 15CM )     10YR 5/2 ; WET      ;  SANDY CLAY LOAM ; LOW      ORGANIC MATTER CONTENT
                    MASSIV   STRUCTURE ,
                    MANY     FINE     DISTINCT MOTTLE (  7.5YR 5/3)
                    FRIABLE                    , SLIGHTLY STICKY , SLIGHTLY PLASTIC
                    COMPACTNESS - SHALLOW FINGER-PRINT ,   23 MM CONE PENETRATION
                    FEW       HORIZONTAL  ROOTS OF  DECIDUOUS TREE
                    DOMINANT STONE - FEW      S.PEBBLE   VERY   WEATHERED, ANGULAR      SHAPED, DERIVED FROM GRANITE
                    ABRUPT    SMOOTH    BOUNDARY ;
```

**************CHEMICAL DATA**************

HOR		PH H2O	PH KCL	EXTR.BASES K	EXTR.BASES NA	EXTR.BASES CA	EXTR.BASES MG	EXTR.BASES SUM	CEC	BASE -SAT.	TOTAL C	TOTAL N	TOTAL C/N	TOTAL P2O5	P2O5 -ABS.
				<---	MEQ/100GSOIL				--->	<---	%	--->		<--- MG/100GSOIL	--->
1.	I	4.33	3.72	0.29	0.11	1.90	1.26	3.56	13.30	26.8	0.53	0.101	5.25	36.3	459.2
2.	I	4.71	3.75	0.14	0.11	1.81	1.22	3.28	11.07	29.6	0.25	0.056	4.46	33.2	397.8
3.	I	4.81	3.79	0.05	0.13	1.54	1.32	3.04	7.93	38.3	0.24	0.037	6.49	26.9	428.6

HOR	AV. P2O5	AV. SIO2	FREE OXIDES MNO2	FREE OXIDES FE2O3	FREE OXIDES AL2O3
	<-MG/100GSOIL	->	<---	%	--->
1.	I****************		***********************		
2.	I****************		***********************		
3.	I****************		***********************		

**************PHYSICAL DATA**************

HOR		BULK -DENS.	PART. -DENS.	H2O -CONT.	PORE	H2O -SAT.	MECHANICAL ANALYSIS C.SAND	F.SAND	SILT	CLAY	TEXT
				<---			%			--->	
1.	I	0.98	2.70	30.1	63.7	46.3	27.5	35.9	18.9	17.8	SCL
2.	I	1.14	2.69	29.6	57.7	58.4	23.2	35.5	18.7	17.6	SCL
3.	I	1.55	2.73	23.7	43.2	85.0	35.4	30.7	15.4	18.5	SCL

Appendix II

Profile Descriptions and Analytical Data for the Representative Soils in the Lowland

1. Mapping unit 1

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* PREFECTURE,COUNTY          ;  KYOTO-FU,YOZA-GUN,KAYA-CHO
* PHYSIOGRAPHIC REGION       ;  KAYA-DANI
* SURVEY                     ;NAME(  KAYA'77     )   DATE(NOV.'77 )  OBSERVER(  KOTA  )
* PROFILE NO.                ; 246
* TYPE OF PROFILE            ;       PIT
* TYPE OF DESCRIPTION        ;    DETAILED
* PARENT MATERIAL            ;
* LAND USE                   ;       ARABLE    -      LOWLAND PADDY      -        SINGLE
* LAND FORM                  ;    MOUNTAINOUS  -    LOWLAND     -    FLOOD PLAIN
* TOPOGRAPHICAL DATA         ;  SLOPE               ASPECT              ELEVATION           WATER TABLE
                                      0 DEGREE                               8 M                   CM
* EROSION                    ;  CLASS                                   TYPE
                                   NONE TO SLIGHT
* DRAINAGE                   ;  RUNOFF              INTERNAL            SOIL DRANAGE
                                   V.SLOW              V.SLOW                    POORLY        DRAINED
* TAXONOMIC UNIT,            ;     GLL  -   0   -   0   -  ALL

1    A1p( 12CM )     5Y 5/1 ; V.WET    ;  SILTY CLAY LOAM ; MEDIUM   ORGANIC MATTER CONTENT
                 MASSIV   STRUCTURE ,                   ( BREAKES TO WEAKLY   DEVELOPED V.FINE   BLOCKY   STRUCTURE )
                 MANY     FINE     DISTINCT MOTTLE (  7.5YR 5/6)
                 FRIABLE (HARD    WHEN DRY) , MODERAT. STICKY , MODERAT. PLASTIC
                 COMPACTNESS - DEEP FINGER-PRINT    ,   10 MM CONE PENETRATION
                 MANY       UBIQUITOUS ROOTS OF       GRASS
                 DOMINANT STONE - FEW      GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED, DERIVED FROM GRANITE
                 ABRUPT    SMOOTH    BOUNDARY ;

2    A12(  7CM )     10Y 5/1 ; WET      ;    LIGHT CLAY    ; LOW      ORGANIC MATTER CONTENT
                 MASSIV   STRUCTURE ,                   ( BREAKES TO WEAKLY   DEVELOPED COARSE   BLOCKY   STRUCTURE )
                 ABUNDANT MEDIUM   DISTINCT MOTTLE (  7.5YR 5/6)
                 FRIABLE (HARD    WHEN DRY) , MODERAT. STICKY ,    VERY   PLASTIC
                 COMPACTNESS - SHALLOW FINGER-PRINT ,   15 MM CONE PENETRATION
                 FEW       VERTICAL     ROOTS OF      GRASS
                 DOMINANT STONE - FEW      GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED, DERIVED FROM GRANITE
                 FERROUS ION COLOR IS MODERAT. APPEARED ;
                 CLEAR     SMOOTH    BOUNDARY ;

3    GR1( 13CM )     5G 4/1 ; WET       ;    LIGHT CLAY    ; LOW      ORGANIC MATTER CONTENT
                 MASSIV   STRUCTURE ,
                 MANY     MEDIUM   PROMINET MOTTLE (   2.5Y 5/6)
                 FRIABLE                  ,  VERY   STICKY ,    VERY   PLASTIC
                 COMPACTNESS - SHALLOW FINGER-PRINT ,   20 MM CONE PENETRATION
                 DOMINANT STONE - MANY     GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED, DERIVED FROM GRANITE
                 FERROUS ION COLOR IS IMMEDIAT APPEARED ;
                 CLEAR     SMOOTH    BOUNDARY ;
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4 GR_2 (25CM+) 10Y 3/1 ; WET ; LIGHT CLAY ; LOW ORGANIC MATTER CONTENT
MASSIV STRUCTURE ,
FEW MEDIUM PROMINET MOTTLE (10YR 5/6)
FRIABLE , VERY STICKY , VERY PLASTIC
COMPACTNESS - SHALLOW FINGER-PRINT , 16 MM CONE PENETRATION
DOMINANT STONE - FEW GRAVEL SLIGHTLY WEATHERED, SUBANGULAR , SHAPED, DERIVED FROM GRANITE
FERROUS ION COLOR IS IMMEDIAT APPEARED ;

************CHEMICAL DATA************

HOR	-----PH----- H2O	KCL	------EXTR.BASES------ K	NA	CA	MG	SUM	CEC	BASE -SAT.	------TOTAL------ C	N	C/N	P2O5	P2O5 -ABS.
			<------MEQ/100GSOIL					------>	<-----	-----%-----	----->		<--MG/100GSOIL-->	
1. I	4.80	4.20	0.32	0.16	4.61	1.49	6.58	14.89	44.2	3.10	0.193	16.07	116.0	********
2. I	********	********	********	********	********	********	********	********	********	********	********	********	********	********
3. I	4.80	4.20	0.07	0.16	3.83	1.40	5.46	9.26	59.0	********	********	********	********	********
4. I	********	********	********	********	********	********	********	********	********	********	********	********	********	********

HOR	AV. P2O5	AV. SIO2	------FREE OXIDES------ MNO2	FE2O3	AL2O3
	<-MG/100GSOIL->		<------	----%----	------>
1. I	29.120	15.650	0.024	3.929	1.333
2. I	********	********	********	********	********
3. I	********	********	********	********	********
4. I	********	********	********	********	********

************PHYSICAL DATA************

HOR	BULK -DENS.	PART. -DENS.	H2O -CONT.	PORE	H2O -SAT.	-----MECHANICAL ANALYSIS----- C.SAND	F.SAND	SILT	CLAY	TEXT
			<------			----%----			------>	
1. I	0.90	2.54	59.8	64.7	82.8	********	********	********	********	****
2. I	********	********	********	********	********	********	********	********	********	****
3. I	1.43	2.63	30.1	45.7	94.1	********	********	********	********	****
4. I	********	********	********	********	********	********	********	********	********	****

2. Mapping unit 2

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* PREFECTURE,COUNTY          ;   KYOTO-FU>YOZA-GUN,KAYA-CHO
* PHYSIOGRAPHIC REGION       ;   KAYA-DANI
* SURVEY                     ;NAME(   KAYA'77      )    DATE(NOV.'77 )   OBSERVER(  KOTA  )
* PROFILE NO.                ;  225
* TYPE OF PROFILE            ;       PIT
* TYPE OF DESCRIPTION        ;     DETAILED
* PARENT MATERIAL            ;
* LAND USE                   ;       ARABLE    -      LOWLAND PADDY                  SINGLE
* LAND FORM                  ;     MOUNTAINOUS  -   LOWLAND     -    FLOOD PLAIN
* TOPOGRAPHICAL DATA         ;   SLOPE               ASPECT              ELEVATION          WATER TABLE
                                      O DEGREE                                10 M                  CM
* EROSION                    ;   CLASS                                     TYPE
                                    NONE TO SLIGHT
* DRAINAGE                   ;   RUNOFF              INTERNAL            SOIL DRANAGE
                                    V.SLOW               SLOW                        POORLY       DRAINED
* TAXONOMIC UNIT,            ;      GRL  -    O    -    O    -   ALL

1      A1p ( 14CM )     2.5Y 5/1 ; V.WET    ;  SILTY CLAY LOAM ; MEDIUM   ORGANIC MATTER CONTENT
                    MASSIV   STRUCTURE ,
                    ABUNDANT MEDIUM   DISTINCT MOTTLE (  7.5YR 5/8)
                    FRIABLE (SL.HARD WHEN DRY) , SLIGHTLY STICKY , MODERAT. PLASTIC
                    COMPACTNESS - FINGER PENETRABLE     ,    8 MM CONE PENETRATION
                    MANY       UBIQUITOUS ROOTS OF      GRASS
                    ABRUPT    SMOOTH    BOUNDARY ;

2      A12 ( 10CM )       5Y 5/1 ; WET      ;      CLAY LOAM    ; LOW      ORGANIC MATTER CONTENT
                    MASSIV   STRUCTURE ,
                    MANY     MEDIUM   PROMINET MOTTLE (  7.5YR 5/8)
                    FRIABLE                  , SLIGHTLY STICKY , SLIGHTLY PLASTIC
                    COMPACTNESS - SHALLOW FINGER-PRINT ,   20 MM CONE PENETRATION
                    FEW       VERTICAL    ROOTS OF      GRASS
                    FERROUS ION COLOR IS SLOWLY   APPEARED ;
                    CLEAR     SMOOTH    BOUNDARY ;

3      C   ( 30CM+)     2.5Y 5/1 ; WET      ;  SILTY CLAY LOAM ; LOW      ORGANIC MATTER CONTENT
                    MASSIV   STRUCTURE ,
                    FEW      COARSE   DISTINCT MOTTLE (   10YR 5/8) ; FEW      FINE      DISTINCT CUTAN (   2.5Y 5/1)
                    FRIABLE (V.HARD  WHEN DRY) , SLIGHTLY STICKY , MODERAT. PLASTIC
                    COMPACTNESS - SHALLOW FINGER-PRINT ,   18 MM CONE PENETRATION
                    FEW       VERTICAL    ROOTS OF      GRASS
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************CHEMICAL DATA************

HOR		PH H_2O	PH KCL	EXTR. BASES K	EXTR. BASES NA	EXTR. BASES CA	EXTR. BASES MG	EXTR. BASES SUM	CEC	BASE -SAT.	TOTAL C	TOTAL N	TOTAL C/N	TOTAL P_2O_5	P_2O_5 -ABS.
				<----	MEQ/100GSOIL				---->	<----	%	---->		<--MG/100GSOIL	-->
1.	I	5.40	4.40	0.30	0.12	4.18	1.51	6.11	9.96	61.3	1.59	0.128	12.38	91.0	********
2.	I	********	********	********	********	********	********	********	********	********	********	********	********	********	********
3.	I	6.10	5.10	0.07	0.19	5.65	3.72	9.63	11.66	82.6	********	********	********	********	********

HOR		AV. P_2O_5	AV. SiO_2	FREE OXIDES MnO_2	FREE OXIDES Fe_2O_3	FREE OXIDES Al_2O_3
		<-MG/100GSOIL	->	<----	%	---->
1.	I	26.500	10.220	0.035	3.299	1.298
2.	I	********	********	********	********	********
3.	I	********	********	********	********	********

************PHYSICAL DATA************

HOR		BULK -DENS.	PART. -DENS.	H_2O -CONT.	PORE	H_2O -SAT.	MECHANICAL ANALYSIS C.SAND	MECHANICAL ANALYSIS F.SAND	MECHANICAL ANALYSIS SILT	MECHANICAL ANALYSIS CLAY	TEXT
				<----			%			---->	
1.	I	0.90	2.56	64.9	64.9	90.0	********	********	********	********	****
2.	I	1.31	2.67	36.9	50.9	94.9	********	********	********	********	****
3.	I	********	********	********	********	********	********	********	********	********	****

3. Mapping unit 3

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* PREFECTURE,COUNTY            ;  KYOTO-FU,YOZA-GUN,KAYA-CHO

* PHYSIOGRAPHIC REGION         ;  KAYA-DANI

* SURVEY                       ;NAME(  KAYA'77     )    DATE(NOV.'77 )   OBSERVER(  KOTA  )

* PROFILE NO.                  ; 177

* TYPE OF PROFILE              ;      PIT

* TYPE OF DESCRIPTION          ;    DETAILED

* PARENT MATERIAL              ;

* LAND USE                     ;      ARABLE    -       LOWLAND PADDY      -           SINGLE

* LAND FORM                    ;    MOUNTAINOUS  -   LOWLAND    -    FLOOD PLAIN

* TOPOGRAPHICAL DATA           ;  SLOPE               ASPECT              ELEVATION          WATER TABLE
                                        0 DEGREE                                9 M               40 CM

* EROSION                      ;  CLASS                                     TYPE
                                     NONE TO SLIGHT

* DRAINAGE                     ;  RUNOFF              INTERNAL            SOIL DRANAGE
                                     PONDED                 SLOW                     POORLY       DRAINED

* TAXONOMIC UNIT,              ;     GLL  -   O   -   O   -   ALL

1      A1p ( 14CM )      5Y 4/1 ; V.WET    ;       LOAM      ; MEDIUM   ORGANIC MATTER CONTENT
                    MASSIV   STRUCTURE ,
                    MANY     MEDIUM   DISTINCT MOTTLE (   10YR 5/8)
                    FRIABLE (SL.HARD WHEN DRY) , SLIGHTLY STICKY ,   VERY   PLASTIC
                    COMPACTNESS - FINGER PENETRABLE    ,    6 MM CONE PENETRATION
                    MANY      UBIQUITOUS ROOTS OF      GRASS
                    ABRUPT    SMOOTH    BOUNDARY ;

2      A12(  8CM )      10Y 5/1 ; V.WET    ;     CLAY LOAM    ; LOW      ORGANIC MATTER CONTENT
                    MASSIV   STRUCTURE ,
                    MANY     COARSE   PROMINET MOTTLE (  7.5YR 5/8)
                    FRIABLE                    , SLIGHTLY STICKY , MODERAT. PLASTIC
                    COMPACTNESS - SHALLOW FINGER-PRINT ,   17 MM CONE PENETRATION
                    FEW       VERTICAL    ROOTS OF      GRASS
                    FERROUS ION COLOR IS IMMEDIAT APPEARED ;
                    CLEAR     SMOOTH    BOUNDARY ;

3      GO ( 22CM )     7.5Y 5/1 ; WET      ;     CLAY LOAM    ; LOW      ORGANIC MATTER CONTENT
                    MASSIV   STRUCTURE ,
                    MANY     MEDIUM   DISTINCT MOTTLE (   10YR 6/8)
                    FRIABLE (HARD    WHEN DRY) , SLIGHTLY STICKY , MODERAT. PLASTIC
                    COMPACTNESS - SHALLOW FINGER-PRINT ,   16 MM CONE PENETRATION
                    FERROUS ION COLOR IS MODERAT. APPEARED ;
                    ABRUPT    SMOOTH    BOUNDARY ;
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4 GR (8CM+) 5Y 6/1 ; V.WET ; LOAMY SAND ; LOW ORGANIC MATTER CONTENT
SNG.GRA. STRUCTURE ,
FEW FINE DISTINCT MOTTLE (10YR 5/8)
V.FRIAB. , NON- STICKY , NON- PLASTIC
COMPACTNESS - SHALLOW FINGER-PRINT ,
FERROUS ION COLOR IS MODERAT. APPEARED ;

************CHEMICAL DATA************

HOR	-----PH----- H2O	KCL	------------EXTR.BASES----------- K	NA	CA	MG	SUM	CEC	BASE -SAT.	------------TOTAL------------ C	N	C/N	P2O5	P2O5 -ABS.
			<-------------MEQ/100GSOIL-------------					>	<----------	%---------	>		<--MG/100GSOIL	-->
1.	I 5.10	4.30	0.22	0.15	2.34	1.27	3.98	11.24	35.4	2.08	0.187	11.11	86.0	********
2.	I********	********	********	********	********	********	********	********	********	********	********	********	********	********
3.	I 5.40	4.50	0.07	0.17	3.70	1.47	5.41	12.91	41.9	********	********	********	********	********
4.	I********	********	********	********	********	********	********	********	********	********	********	********	********	********

HOR	AV. P2O5	AV. SIO2	------FREE OXIDES------ MNO2	FE2O3	AL2O3
	<-MG/100GSOIL->		<----------	%----------	>
1.	I 30.370	7.530	0.023	4.157	0.622
2.	I********	********	********	********	********
3.	I********	********	********	********	********
4.	I********	********	********	********	********

************PHYSICAL DATA************

HOR	BULK -DENS.	PART. -DENS.	H2O -CONT.	PORE	H2O -SAT.	-----MECHANICAL ANALYSIS----- C.SAND	F.SAND	SILT	CLAY	TEXT
			<------------	------------	------------	%	------------	------------	------------>	
1.	I 0.95	2.52	60.9	62.1	93.6	********	********	********	********	****
2.	I********	********	********	********	********	********	********	********	********	****
3.	I 1.27	2.63	40.2	51.7	98.6	********	********	********	********	****
4.	I********	********	********	********	********	********	********	********	********	****

4. Mapping unit 4

* PREFECTURE,COUNTY ; KYOTO-FU,YOZA-GUN,KAYA-CHO
* PHYSIOGRAPHIC REGION ; KAYA-DANI
* SURVEY ;NAME(KAYA'77) DATE(NOV.'77) OBSERVER(KOTA)
* PROFILE NO. ; 251
* TYPE OF PROFILE ; PIT
* TYPE OF DESCRIPTION ; DETAILED
* PARENT MATERIAL ; GRANITE
* LAND USE ; ARABLE - LOWLAND PADDY - SINGLE
* LAND FORM ; MOUNTAINOUS - TERRACE-FAN - FAN
* TOPOGRAPHICAL DATA ; SLOPE / DEGREE ; ASPECT S80W ; ELEVATION 20 M ; WATER TABLE CM
* EROSION ; CLASS NONE TO SLIGHT ; TYPE
* DRAINAGE ; RUNOFF MEDIUM ; INTERNAL SLOW ; SOIL DRANAGE INPERFECTLY DRAINED
* TAXONOMIC UNIT, ; GRL - O - O - ALL

1 $A1_p$ (13CM) 2.5Y 5/2 ; V.WET ; CLAY LOAM ; MEDIUM ORGANIC MATTER CONTENT
MASSIV STRUCTURE ,
MANY FINE DISTINCT MOTTLE (7.5YR 5/6)
FRIABLE (SL.HARD WHEN DRY) , MODERAT. STICKY , VERY PLASTIC
COMPACTNESS - DEEP FINGER-PRINT , 12 MM CONE PENETRATION
MANY UBIQUITOUS ROOTS OF GRASS
DOMINANT STONE - FEW GRAVEL SLIGHTLY WEATHERED, SUBANGULAR SHAPED, DERIVED FROM GRANITE
ABRUPT SMOOTH BOUNDARY ;

2 $A1_2$ (8CM) 7.5Y 5/1 ; WET ; SANDY CLAY LOAM ; LOW ORGANIC MATTER CONTENT
MASSIV STRUCTURE , (BREAKES TO WEAKLY DEVELOPED COARSE BLOCKY STRUCTURE)
MANY MEDIUM PROMINET MOTTLE (7.5YR 5/8)
FIRM (V.HARD WHEN DRY) , MODERAT. STICKY , MODERAT. PLASTIC
COMPACTNESS - SHALLOW FINGER-PRINT , 18 MM CONE PENETRATION
FEW VERTICAL ROOTS OF GRASS
DOMINANT STONE - FEW GRAVEL SLIGHTLY WEATHERED, SUBANGULAR SHAPED, DERIVED FROM GRANITE
FERROUS ION COLOR IS IMMEDIAT APPEARED ;
GRADUAL SMOOTH BOUNDARY ;

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3      GO ( 25CM+)        5Y 5/1 ; WET       ;  SANDY CLAY LOAM ; LOW      .ORGANIC MATTER CONTENT
                 MASSIV   STRUCTURE ,                               ( BREAKES TO WEAKLY   DEVELOPED V.COARSE BLOCKY   STRUCTURE )
                 FEW      MEDIUM   DISTINCT MOTTLE (   10YR 5/6) ; FEW      FINE     DISTINCT CUTAN (     5Y 5/1)
                 FRIABLE                    , MODERAT. STICKY ,    VERY   PLASTIC
                 COMPACTNESS - SHALLOW FINGER-PRINT ,   18 MM CONE PENETRATION
                 DOMINANT STONE - FEW      GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED, DERIVED FROM GRANITE
                 FERROUS ION COLOR IS IMMEDIAT APPEARED ;
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************CHEMICAL DATA************

HOR		-----PH----- H2O	KCL	------------EXTR.BASES------------ K	NA	CA	MG	SUM	CEC	BASE -SAT.	------------TOTAL------------ C	N	C/N	P2O5	P2O5 -ABS.
				<-------------	-------------	MEQ/100GSOIL	-------------	------------->		<----------	%---------	--------->		<--MG/100GSOIL	-->
1.	I	5.40	4.30	0.52	0.10	3.23	1.36	5.21	8.99	58.0	0.81	0.106	7.62	49.0	********
2.	I	5.00	4.10	0.21	0.12	2.15	1.24	3.72	8.06	46.2	********	********	********	********	********
3.	I	********	********	********	********	********	********	********	********	********	********	********	********	********	********

HOR		AV. P2O5	AV. SIO2	------FREE OXIDES------ MNO2	FE2O3	AL2O3
		<-MG/100GSOIL->		<----------	%----------	---------->
1.	I	2.680	19.720	0.031	3.455	1.050
2.	I	********	********	********	********	********
3.	I	********	********	********	********	********

************PHYSICAL DATA************

HOR		BULK -DENS.	PART. -DENS.	H2O -CONT.	PORE	H2O -SAT.	-----MECHANICAL ANALYSIS----- C.SAND	F.SAND	SILT	CLAY	TEXT
				<-------------	-------------	-------------	%-------------	-------------	-------------	------------->	
1.	I	1.31	2.62	30.7	50.0	80.4	********	********	********	********	****
2.	I	1.59	2.61	23.1	38.9	94.3	********	********	********	********	****
3.	I	********	********	********	********	********	********	********	********	********	****

5. Mapping unit 5

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* PREFECTURE,COUNTY          ;  KYOTO-FU,YOZA-GUN,KAYA-CHO
* PHYSIOGRAPHIC REGION       ;  KAYA-DANI
* SURVEY                     ;NAME(  KAYA'77     )   DATE(NOV.'77 )  OBSERVER(  KOTA  )
* PROFILE NO.                ; 157
* TYPE OF PROFILE            ;      PIT
* TYPE OF DESCRIPTION        ;    DETAILED
* PARENT MATERIAL            ;
* LAND USE                   ;      ARABLE    -     LOWLAND PADDY     -         SINGLE
* LAND FORM                  ;    MOUNTAINOUS  -  TERRACE-FAN  -  LOW TERRACE
* TOPOGRAPHICAL DATA         ;  SLOPE              ASPECT             ELEVATION          WATER TABLE
                                      2 DEGREE       N70W                22 M                 CM
* EROSION                    ;  CLASS                                  TYPE
                                   NONE TO SLIGHT
* DRAINAGE                   ;  RUNOFF             INTERNAL           SOIL DRANAGE
                                    SLOW               SLOW                 INPERFECTLY      DRAINED
* TAXONOMIC UNIT,            ;     GRL  -   O   -   O   -  ALL

1      A1p ( 20CM )    2.5Y 4/2 ; V.WET    ;     CLAY LOAM    ; MEDIUM   ORGANIC MATTER CONTENT
                      MASSIV   STRUCTURE ,
                      MANY     FINE     FAINT    MOTTLE (   10YR 5/6)
                      FRIABLE (HARD    WHEN DRY) , SLIGHTLY STICKY , SLIGHTLY PLASTIC
                      COMPACTNESS - FINGER PENETRABLE    ,    8 MM CONE PENETRATION  .
                      MANY       UBIQUITOUS ROOTS OF      GRASS
                      DOMINANT STONE - MANY     GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED, DERIVED FROM GRANITE
                      FERROUS ION COLOR IS SLOWLY   APPEARED ;
                      ABRUPT    SMOOTH    BOUNDARY ;

2      A12 (  6CM )    7.5Y 4/1 ; WET      ;     CLAY LOAM    ; LOW      ORGANIC MATTER CONTENT
                      MASSIV   STRUCTURE ,
                      FEW      MEDIUM   PROMINET MOTTLE (  7.5YR 5/6)
                      FRIABLE                    , SLIGHTLY STICKY , MODERAT. PLASTIC
                      COMPACTNESS - DEEP FINGER-PRINT    ,   17 MM CONE PENETRATION
                      DOMINANT STONE - MANY     GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED, DERIVED FROM GRANITE
                      FERROUS ION COLOR IS MODERAT. APPEARED ;
                      ABRUPT    SMOOTH    BOUNDARY ;

3      B2 (  5CM )     2.5Y 4/3 ; WET      ;    LIGHT CLAY    ; LOW      ORGANIC MATTER CONTENT
                      MASSIV   STRUCTURE ,
                      ABUNDANT FINE     DISTINCT MOTTLE (   10YR 5/6)
                      FRIABLE (V.HARD  WHEN DRY) , MODERAT. STICKY , MODERAT. PLASTIC
                      COMPACTNESS - SHALLOW FINGER-PRINT ,   13 MM CONE PENETRATION
                      DOMINANT STONE - FEW      GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED, DERIVED FROM GRANITE
                      FERROUS ION COLOR IS SLOWLY   APPEARED ;   FE IS SLIGHTLY ACCUMULATED
                      CLEAR     SMOOTH    BOUNDARY ;
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4 C (25CM+) 2.5Y 3/1 ; WET ; HEAVY CLAY ; MEDIUM ORGANIC MATTER CONTENT
MASSIV STRUCTURE ,
MANY MEDIUM PROMINET MOTTLE (10YR 5/6)
FRIABLE , MODERAT. STICKY , VERY PLASTIC
COMPACTNESS - SHALLOW FINGER-PRINT , 15 MM CONE PENETRATION
DOMINANT STONE - MANY GRAVEL SLIGHTLY WEATHERED, SUBANGULAR SHAPED, DERIVED FROM GRANITE
FERROUS ION COLOR IS MODERAT. APPEARED ;

************CHEMICAL DATA************

HOR		-----PH----- H2O	KCL	------EXTR.BASES------ K	NA	CA	MG	SUM	CEC	BASE -SAT.	------TOTAL------ C	N	C/N	P2O5	P2O5 -ABS.
				<------MEQ/100GSOIL------>						<------%------>				<--MG/100GSOIL-->	
1.	I	5.50	4.60	0.41	0.12	5.64	1.76	7.93	16.73	47.4	2.79	0.259	10.78	115.0	********
2.	I	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
3.	I	5.10	4.20	0.12	0.14	4.12	1.09	5.47	13.94	39.2	*****	*****	*****	*****	*****
4.	I	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****

HOR		AV. P2O5	AV. SIO2	------FREE OXIDES------ MNO2	FE2O3	AL2O3
		<-MG/100GSOIL->		<------%------>		
1.	I	51.140	19.910	0.020	2.556	0.931
2.	I	********	********	********	********	********
3.	I	********	********	********	********	********
4.	I	********	********	********	********	********

************PHYSICAL DATA************

HOR		BULK -DENS.	PART. -DENS.	H2O -CONT.	PORE	H2O -SAT.	-----MECHANICAL ANALYSIS----- C.SAND	F.SAND	SILT	CLAY	TEXT
				<------------%------------>							
1.	I	0.86	2.51	71.7	65.9	93.2	********	********	********	********	****
2.	I	********	********	********	********	********	********	********	********	********	****
3.	I	********	********	********	********	********	********	********	********	********	****
4.	I	1.23	2.55	42.0	51.8	99.6	********	********	********	********	****

6. Mapping unit 6

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* PREFECTURE,COUNTY            ;   KYOTO-FU,YOZA-GUN,KAYA-CHO

* PHYSIOGRAPHIC REGION         ;   KAYA-DANI

* SURVEY                       ;NAME(   KAYA'77      )    DATE(NOV.'77 )   OBSERVER(  KOTA  )

* PROFILE NO.                  ;  158

* TYPE OF PROFILE              ;        PIT

* TYPE OF DESCRIPTION          ;     DETAILED

* PARENT MATERIAL              ;

* LAND USE                     ;        ARABLE     -        LOWLAND PADDY       -             SINGLE

* LAND FORM                    ;     MOUNTAINOUS   -  TERRACE-FAN   -  MIDDLE TERRACE

* TOPOGRAPHICAL DATA           ;   SLOPE              ASPECT             ELEVATION          WATER TABLE
                                        10 DEGREE         S60W                35 M                   CM

* EROSION                      ;   CLASS                                   TYPE
                                      NONE TO SLIGHT

* DRAINAGE                     ;   RUNOFF             INTERNAL           SOIL DRANAGE
                                      MEDIUM              SLOW                 INPERFECTLY      DRAINED

* TAXONOMIC UNIT,              ;      GRL  -    O    -    O    -    RG

1      A1p( 15CM )      5Y 4/1 ; V.WET    ;     CLAY LOAM    ; MEDIUM   ORGANIC MATTER CONTENT
                  MASSIV   STRUCTURE ,                            ( BREAKES TO WEAKLY   DEVELOPED COARSE   BLOCKY   STRUCTURE )
                  MANY     MEDIUM   DISTINCT MOTTLE (   10YR 5/8)
                  FRIABLE (SL.HARD WHEN DRY) , SLIGHTLY STICKY , MODERAT. PLASTIC
                  COMPACTNESS - FINGER PENETRABLE     ,   13 MM CONE PENETRATION
                  MANY       UBIQUITOUS ROOTS OF       GRASS
                  DOMINANT STONE - MANY     GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED, DERIVED FROM GRANITE
                  FERROUS ION COLOR IS SLOWLY   APPEARED ;
                  ABRUPT     SMOOTH    BOUNDARY ;

2      A12(  6CM )     10Y 5/1 ; WET     ;  SANDY CLAY LOAM ; LOW      ORGANIC MATTER CONTENT
                  WEAKLY   DEVELOPED,MEDIUM    BLOCKY    STRUCTURE ,
                  MANY     MEDIUM   PROMINET MOTTLE (   10YR 5/8)
                  FRIABLE                      , SLIGHTLY STICKY , MODERAT. PLASTIC
                  COMPACTNESS - DEEP FINGER-PRINT    ,   16 MM CONE PENETRATION
                  FEW      VERTICAL     ROOTS OF       GRASS
                  DOMINANT STONE - MANY     GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED, DERIVED FROM GRANITE
                  FERROUS ION COLOR IS MODERAT. APPEARED ;
                  CLEAR      SMOOTH    BOUNDARY ;

3      B2 ( 10CM )    2.5Y 5/6 ; WET     ;    LIGHT CLAY    ; LOW      ORGANIC MATTER CONTENT
                  WEAKLY   DEVELOPED,FINE     BLOCKY    STRUCTURE ,
                  MANY     MEDIUM   DISTINCT MOTTLE (   10YR 5/6)
                  FRIABLE (HARD    WHEN DRY) , MODERAT. STICKY ,   VERY   PLASTIC
                  COMPACTNESS - FINGER PENETRABLE    ,   13 MM CONE PENETRATION
                  DOMINANT STONE - MANY     GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED, DERIVED FROM GRANITE
                  FERROUS ION COLOR IS MODERAT. APPEARED ;   FE IS MODERAT. ACCUMULATED
                  CLEAR      SMOOTH    BOUNDARY ;
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4     C1 ( 10CM )      10Y 7/1 ; WET        ;     LIGHT CLAY      ; LOW       ORGANIC MATTER CONTENT
                   WEAKLY   DEVELOPED,MEDIUM     BLOCKY     STRUCTURE ,
                   FEW      COARSE    DISTINCT MOTTLE (    10YR 5/8)
                   FRIABLE (HARD     WHEN DRY) , MODERAT. STICKY , MODERAT. PLASTIC
                   COMPACTNESS -   NON-FINGER-PRINT    ,   27 MM CONE PENETRATION
                   DOMINANT STONE - ABUNDANT GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED, DERIVED FROM GRANITE
                   CLEAR      WAVY       BOUNDARY ;

5     C2 (  5CM+)   -       */* ; WET        ;     HEAVY CLAY      ; LOW       ORGANIC MATTER CONTENT
                   MASSIV   STRUCTURE ,
                   MANY     MEDIUM   DISTINCT MOTTLE (    10YR 5/8)
                   FRIABLE                     ,   VERY    STICKY ,    VERY   PLASTIC
                   COMPACTNESS -   NON-FINGER-PRINT    ,   25 MM CONE PENETRATION
                   DOMINANT STONE - MANY     GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED, DERIVED FROM GRANITE
```

************CHEMICAL DATA************

HOR	PH H2O	PH KCL	EXTR.BASES K	EXTR.BASES NA	EXTR.BASES CA	EXTR.BASES MG	EXTR.BASES SUM	CEC	BASE -SAT.	TOTAL C	TOTAL N	TOTAL C/N	TOTAL P2O5	P2O5 -ABS.
			<---MEQ/100GSOIL					--->	<---%		--->		<--MG/100GSOIL-->	
1.	5.00	4.20	0.17	0.10	2.31	1.07	3.65	9.42	38.7	1.42	0.157	9.02	75.0	********
2.	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
3.	5.50	4.70	0.13	0.20	4.70	1.28	6.31	9.49	66.5	*****	*****	*****	*****	*****
4.	5.90	5.10	0.12	0.19	4.70	1.47	6.48	7.42	87.3	*****	*****	*****	*****	*****
5.	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****

HOR	AV. P2O5	AV. SIO2	FREE OXIDES MNO2	FREE OXIDES FE2O3	FREE OXIDES AL2O3
	<-MG/100GSOIL->		<---%		--->
1.	26.110	4.150	0.012	1.642	0.586
2.	*****	*****	*****	*****	*****
3.	*****	*****	*****	*****	*****
4.	*****	*****	*****	*****	*****
5.	*****	*****	*****	*****	*****

************PHYSICAL DATA************

HOR	BULK -DENS.	PART. -DENS.	H2O -CONT.	PORE	H2O -SAT.	MECHANICAL ANALYSIS C.SAND	MECHANICAL ANALYSIS F.SAND	MECHANICAL ANALYSIS SILT	MECHANICAL ANALYSIS CLAY	TEXT
			<---%						--->	
1.	1.08	2.53	52.1	57.3	98.3	*****	*****	*****	*****	****
2.	*****	*****	*****	*****	*****	*****	*****	*****	*****	****
3.	1.29	2.59	38.3	50.1	98.8	*****	*****	*****	*****	****
4.	1.41	2.61	31.8	46.1	97.0	*****	*****	*****	*****	****
5.	*****	*****	*****	*****	*****	*****	*****	*****	*****	****

7. Mapping unit 7

* PREFECTURE,COUNTY ; KYOTO-FU,YOZA-GUN,KAYA-CHO

* PHYSIOGRAPHIC REGION ; KAYA-DANI

* SURVEY ;NAME(KAYA'77) DATE(NOV.'77) OBSERVER(KOTA)

* PROFILE NO. ; 145

* TYPE OF PROFILE ; PIT

* TYPE OF DESCRIPTION ; DETAILED

* PARENT MATERIAL ;

* LAND USE ; ARABLE - LOWLAND PADDY - SINGLE

* LAND FORM ; MOUNTAINOUS - LOWLAND - FLOOD PLAIN

* TOPOGRAPHICAL DATA ; SLOPE 0 DEGREE ASPECT ELEVATION 17 M WATER TABLE 45 CM

* EROSION ; CLASS NONE TO SLIGHT TYPE

* DRAINAGE ; RUNOFF V.SLOW INTERNAL MEDIUM SOIL DRANAGE INPERFECTLY DRAINED

* TAXONOMIC UNIT, ; GLL - 0 - 0 - ALL

1 $A1_p$ (13CM) 2.5Y 4/2 ; V.WET ; SANDY CLAY LOAM ; MEDIUM ORGANIC MATTER CONTENT
MASSIV STRUCTURE ,
MANY MEDIUM DISTINCT MOTTLE (10YR 5/8)
FRIABLE , SLIGHTLY STICKY , NON- PLASTIC
COMPACTNESS - FINGER PENETRABLE , 10 MM CONE PENETRATION
MANY UBIQUITOUS ROOTS OF OTHERS
DOMINANT STONE - FEW GRAVEL SLIGHTLY WEATHERED, SUBANGULAR SHAPED,
FERROUS ION COLOR IS SLOWLY APPEARED ;
ABRUPT WAVY BOUNDARY ;

2 GR_1(15CM) 10YR 4/1 ; V.WET ; SANDY LOAM ; LOW ORGANIC MATTER CONTENT
MASSIV STRUCTURE ,
MANY MEDIUM PROMINET MOTTLE (7.5YR 5/6)
FRIABLE (SOFT WHEN DRY) , NON- STICKY , NON- PLASTIC
COMPACTNESS - DEEP FINGER-PRINT , 15 MM CONE PENETRATION
FEW VERTICAL ROOTS OF GRASS
DOMINANT STONE - FEW GRAVEL SLIGHTLY WEATHERED, SUBANGULAR SHAPED,
FERROUS ION COLOR IS IMMEDIAT APPEARED ;

ABRUPT SMOOTH BOUNDARY ;

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3       GR2( 31CM+)     10YR 5/1 ; V.WET    ;       SAND       ; LOW      ORGANIC MATTER CONTENT
                   SNG.GRA. STRUCTURE ,
                   V.FRIAB.                  , NON-     STICKY , NON-     PLASTIC
                   COMPACTNESS - SHALLOW FINGER-PRINT ,   12 MM CONE PENETRATION
                   DOMINANT STONE - ABUNDANT GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED,
                   FERROUS ION COLOR IS IMMEDIAT APPEARED ;


                             ************CHEMICAL  DATA************

        -----PH-----   -----------EXTR.BASES-----------          BASE   -----------TOTAL-----------     P2O5
HOR      H2O    KCL    K      NA     CA     MG     SUM     CEC   -SAT.    C      N      C/N    P2O5   -ABS.

                     <-------------MEQ/100GSOIL------------->  <---------%--------->      <--MG/100GSOIL-->

 1.  I   5.40   4.30   0.31   0.09   2.75   1.40   4.55    9.08   50.1    1.57   0.142  11.09   97.0********
 2.  I   4.90   4.30   0.21   0.13   3.23   1.43   5.00    8.81   56.8****************************************
 3.  I*************************************************************************************************************


        AV.     AV.    ------FREE OXIDES------
HOR     P2O5    SIO2     MNO2   FE2O3   AL2O3

      <-MG/100GSOIL->  <----------%---------->

 1.  I 48.770  4.020     0.021   2.707   0.989
 2.  I***************  ***********************
 3.  I***************  ***********************


                             ************PHYSICAL  DATA************

        BULK    PART.   H2O             H2O     -----MECHANICAL ANALYSIS----
HOR     -DENS.  -DENS.  -CONT.  PORE    -SAT. C.SAND  F.SAND   SILT   CLAY    TEXT

                       <-----------------------%----------------------->

 1.  I   0.96    2.59    60.8    62.8    93.3********************************   ****
 2.  I   1.24    2.58    41.0    51.9    98.1********************************   ****
 3.  I*********************************************************************   ****
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8. Mapping unit 8

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* PREFECTURE,COUNTY          ;  KYOTO-FU,YOZA-GUN,KAYA-CHO

* PHYSIOGRAPHIC REGION       ;  KAYA-DANI

* SURVEY                     ;NAME(   KAYA'77      )    DATE(NOV.'77 )   OBSERVER(  KOTA  )

* PROFILE NO.                ; 150

* TYPE OF PROFILE            ;       PIT

* TYPE OF DESCRIPTION        ;     DETAILED

* PARENT MATERIAL            ;

* LAND USE                   ;       ARABLE     -        LOWLAND PADDY       -            SINGLE

* LAND FORM                  ;     MOUNTAINOUS  -    LOWLAND      -  ALLUVIAL TERRACE

* TOPOGRAPHICAL DATA         ;   SLOPE               ASPECT              ELEVATION            WATER TABLE
                                       2 DEGREE         N70W                  28 M                  75 CM

* EROSION                    ;   CLASS                                    TYPE
                                    NONE TO SLIGHT

* DRAINAGE                   ;   RUNOFF              INTERNAL            SOIL DRANAGE
                                     SLOW                MEDIUM                   MODERATELY      DRAINED

* TAXONOMIC UNIT,            ;      GRL  -   O   -   O  -   ALL
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1     A1p( 18CM )     10YR 4/1 ; V.WET    ;  SANDY CLAY LOAM ; MEDIUM   ORGANIC MATTER CONTENT
                   MASSIV   STRUCTURE ,
                   FEW      FINE     FAINT    MOTTLE (    10YR 5/8)
                   FRIABLE (SL.HARD WHEN DRY) , SLIGHTLY STICKY , MODERAT. PLASTIC
                   COMPACTNESS - FINGER PENETRABLE    ,   12 MM CONE PENETRATION
                   MANY       UBIQUITOUS ROOTS OF      GRASS
                   DOMINANT STONE - FEW      GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED, DERIVED FROM GRANITE
                   FERROUS ION COLOR IS SLOWLY   APPEARED ;
                   ABRUPT    SMOOTH    BOUNDARY ;

2     A12( 12CM )       5Y 4/1 ; V.WET    ;       LOAM       ; LOW      ORGANIC MATTER CONTENT
                   WEAKLY   DEVELOPED,COARSE    BLOCKY    STRUCTURE ,
                   MANY     FINE     DISTINCT MOTTLE (    10YR 5/8)
                   FRIABLE                      , SLIGHTLY STICKY , SLIGHTLY PLASTIC
                   COMPACTNESS - SHALLOW FINGER-PRINT ,   22 MM CONE PENETRATION
                   FEW       VERTICAL     ROOTS OF      GRASS
                   DOMINANT STONE - MANY     GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED, DERIVED FROM GRANITE
                   FERROUS ION COLOR IS SLOWLY   APPEARED ;
                   CLEAR     SMOOTH    BOUNDARY ;

3     B21(  7CM )     2.5Y 4/4 ; WET      ;     CLAY LOAM    ; LOW      ORGANIC MATTER CONTENT
                   WEAKLY   DEVELOPED,COARSE    BLOCKY    STRUCTURE ,
                   ABUNDANT MEDIUM   DISTINCT MOTTLE (    10YR 5/8)
                   FRIABLE (SL.HARD WHEN DRY) , MODERAT. STICKY , MODERAT. PLASTIC
                   COMPACTNESS - SHALLOW FINGER-PRINT ,   20 MM CONE PENETRATION
                   DOMINANT STONE - MANY     GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED, DERIVED FROM GRANITE
                     FE IS MODERAT. ACCUMULATED
                   ABRUPT    SMOOTH    BOUNDARY ;
```

4 B2$_2$(8CM) 10YR 3/4 ; WET ; CLAY LOAM ; LOW ORGANIC MATTER CONTENT
WEAKLY DEVELOPED,COARSE BLOCKY STRUCTURE ,
FEW FINE FAINT MOTTLE (10YR 5/8)
FRIABLE ,·SLIGHTLY STICKY , SLIGHTLY PLASTIC
COMPACTNESS - SHALLOW FINGER-PRINT , 25 MM CONE PENETRATION
DOMINANT STONE - FEW GRAVEL SLIGHTLY WEATHERED, SUBANGULAR SHAPED, DERIVED FROM GRANITE
FEMN IS SLIGHTLY ACCUMULATED
ABRUPT SMOOTH BOUNDARY ;

5 C (30CM+) 10YR 2/1 ; V.WET ; CLAY LOAM ; HIGH ORGANIC MATTER CONTENT
MASSIV STRUCTURE ,
FEW FINE DISTINCT MOTTLE (10YR 5/8)
FRIABLE , SLIGHTLY STICKY , MODERAT. PLASTIC
COMPACTNESS - SHALLOW FINGER-PRINT , 18 MM CONE PENETRATION
FERROUS ION COLOR IS SLOWLY APPEARED ;

************CHEMICAL DATA************

HOR	-----PH----- H2O	KCL	-----------EXTR.BASES----------- K	NA	CA	MG	SUM	CEC	BASE -SAT.	-----------TOTAL----------- C	N	C/N	P2O5	P2O5 -ABS.
			<-------------MEQ/100GSOIL-------------					>	<----------	%--------->			<--MG/100GSOIL-->	
1.	I 5.50	4.60	0.32	0.11	4.51	2.44	7.38	13.76	53.6	2.48	0.227	10.90	114.0	********
2.	I**													
3.	I 5.30	4.40	0.14	0.13	4.78	1.80	6.85	14.51	47.2**************************************					
4.	I**													
5.	I**													

HOR	AV. P2O5	AV. SIO2	------FREE OXIDES------ MNO2	FE2O3	AL2O3
	<-MG/100GSOIL->		<----------	%---------->	
1.	I 26.580	4.860	0.021	2.038	0.629
2.	I****************		***********************		
3.	I****************		***********************		
4.	I****************		***********************		
5.	I****************		***********************		

************PHYSICAL DATA************

HOR	BULK -DENS.	PART. -DENS.	H2O -CONT.	PORE	H2O -SAT.	-----MECHANICAL ANALYSIS----- C.SAND	F.SAND	SILT	CLAY	TEXT
	<----------------------				%----------------------				>	
1.	I 0.95	2.53	61.2	62.3	93.7*******************************					****
2.	I**									****
3.	I 1.36	2.62	34.0	48.2	95.9*******************************					****
4.	I**									****
5.	I**									****

9. Mapping unit 9

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* PREFECTURE,COUNTY          ;   KYOTO-FU,YOZA-GUN,KAYA-CHO
* PHYSIOGRAPHIC REGION       ;   KAYA-DANI
* SURVEY                     ;NAME(   KAYA'77      )    DATE(NOV.'77 )   OBSERVER(  KOTA  )
* PROFILE NO.                ;  142
* TYPE OF PROFILE            ;        PIT
* TYPE OF DESCRIPTION        ;     DETAILED
* PARENT MATERIAL            ;
* LAND USE                   ;        ARABLE     -       LOWLAND PADDY       -            SINGLE
* LAND FORM                  ;     MOUNTAINOUS   -    LOWLAND     -    VALLEY PLAIN
* TOPOGRAPHICAL DATA         ;   SLOPE              ASPECT              ELEVATION           WATER TABLE
                                      2 DEGREE          N                   19 M                70 CM
* EROSION                    ;   CLASS                                   TYPE
                                    NONE TO SLIGHT
* DRAINAGE                   ;   RUNOFF             INTERNAL            SOIL DRANAGE
                                     SLOW               MEDIUM                 MODERATELY      DRAINED
* TAXONOMIC UNIT,            ;    GRL  -   0   -   0   -   ALL

1      A1p ( 15CM )      5Y 4/1 ; V.WET     ;      CLAY LOAM     ; MEDIUM   ORGANIC MATTER CONTENT
                   WEAKLY   DEVELOPED,COARSE    BLOCKY    STRUCTURE ,
                   FRIABLE (SOFT    WHEN DRY) , SLIGHTLY STICKY , SLIGHTLY PLASTIC
                   COMPACTNESS - FINGER PENETRABLE    ,   10 MM CONE PENETRATION
                   MANY      UBIQUITOUS ROOTS OF      GRASS
                   DOMINANT STONE - MANY     GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED, DERIVED FROM GRANITE
                   FERROUS ION COLOR IS SLOWLY   APPEARED ;
                   ABRUPT    SMOOTH    BOUNDARY ;

2      A12 (  5CM )      5Y 4/1 ; V.WET     ;      CLAY LOAM     ; LOW      ORGANIC MATTER CONTENT
                   WEAKLY   DEVELOPED,COARSE    BLOCKY    STRUCTURE ,
                   FRIABLE                      , SLIGHTLY STICKY , SLIGHTLY PLASTIC
                   COMPACTNESS - SHALLOW FINGER-PRINT ,   16 MM CONE PENETRATION
                   FEW       VERTICAL    ROOTS OF      GRASS
                   DOMINANT STONE - FEW      GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED, DERIVED FROM GRANITE
                   FERROUS ION COLOR IS SLOWLY   APPEARED ;
                   ABRUPT    SMOOTH    BOUNDARY ;

3      B2  ( 15CM )     2.5Y 4/3 ; WET      ;     SANDY LOAM     ; LOW      ORGANIC MATTER CONTENT
                   WEAKLY   DEVELOPED,COARSE    BLOCKY    STRUCTURE ,
                   MANY      MEDIUM   DISTINCT MOTTLE (   10YR 5/8)
                   FRIABLE (SL.HARD WHEN DRY) , NON-     STICKY , NON-     PLASTIC
                   COMPACTNESS - SHALLOW FINGER-PRINT ,   20 MM CONE PENETRATION
                   FEW       VERTICAL    ROOTS OF      GRASS
                   DOMINANT STONE - MANY     GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED, DERIVED FROM GRANITE
                   FERROUS ION COLOR IS SLOWLY   APPEARED ;   FE IS MODERAT. ACCUMULATED
                   ABRUPT    SMOOTH    BOUNDARY ;
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4 C1 (10CM) 2.5Y 4/2 ; WET ; LOAMY SAND ; LOW ORGANIC MATTER CONTENT
SNG.GRA. STRUCTURE ,
FEW FINE DISTINCT MOTTLE (10YR 5/8)
V.FRIAB. , NON- STICKY , NON- PLASTIC
COMPACTNESS - SHALLOW FINGER-PRINT , 18 MM CONE PENETRATION
DOMINANT STONE - MANY GRAVEL SLIGHTLY WEATHERED, SUBANGULAR SHAPED, DERIVED FROM GRANITE
FERROUS ION COLOR IS SLOWLY APPEARED ;
ABRUPT SMOOTH BOUNDARY ;

5 C2 (15CM+) 2.5Y 5/3 ; V.WET ; LOAMY SAND ; LOW ORGANIC MATTER CONTENT
SNG.GRA. STRUCTURE ,
V.FRIAB.
COMPACTNESS - DEEP FINGER-PRINT , 13 MM CONE PENETRATION
DOMINANT STONE - MANY GRAVEL SLIGHTLY WEATHERED, SUBANGULAR SHAPED, DERIVED FROM GRANITE
FERROUS ION COLOR IS SLOWLY APPEARED ;

************CHEMICAL DATA************

HOR	-----PH----- H2O	KCL	----------EXTR.BASES---------- K	NA	CA	MG	SUM	CEC	BASE -SAT.	---------TOTAL--------- C	N	C/N	P2O5	P2O5 -ABS.
			<-------------	MEQ/100GSOIL				------------->	<----------	%---------	->		<--MG/100GSOIL-->	
1. I	5.30	4.60	0.14	1.00	3.13	2.43	6.70	9.96	67.3	1.69	0.153	11.08	62.0	********
2. I	******	******	******	******	******	******	******	******	******	******	******	******	******	******
3. I	5.90	4.90	0.07	0.19	2.35	2.50	5.11	7.11	71.9	******	******	******	******	******
4. I	******	******	******	******	******	******	******	******	******	******	******	******	******	******
5. I	******	******	******	******	******	******	******	******	******	******	******	******	******	******

HOR	AV. P2O5	AV. SIO2	------FREE OXIDES------ MNO2	FE2O3	AL2O3
	<-MG/100GSOIL->		<----------	%----------	->
1. I	30.360	3.950	0.014	1.875	0.956
2. I	********	********	********	********	********
3. I	********	********	********	********	********
4. I	********	********	********	********	********
5. I	********	********	********	********	********

************PHYSICAL DATA************

HOR	BULK -DENS.	PART. -DENS.	H2O -CONT.	PORE	H2O -SAT.	-----MECHANICAL ANALYSIS----- C.SAND	F.SAND	SILT	CLAY	TEXT
			<------------	-----------	%------------	-----------	-----------	-----------	->	
1. I	1.01		57.4	73.1	79.2	******	******	******	******	****
2. I	******	******	******	******	******	******	******	******	******	****
3. I	1.51	2.64	25.8	43.0	90.2	******	******	******	******	****
4. I	******	******	******	******	******	******	******	******	******	****
5. I	******	******	******	******	******	******	******	******	******	****

10. Mapping unit 10

* PREFECTURE,COUNTY	; KYOTO-FU,YOZA-GUN,KAYA-CHO
* PHYSIOGRAPHIC REGION	; KAYA-DANI
* SURVEY	;NAME(KAYA'77) DATE(NOV.'77) OBSERVER(KOTA)
* PROFILE NO.	; 207
* TYPE OF PROFILE	; PIT
* TYPE OF DESCRIPTION	; DETAILED
* PARENT MATERIAL	;
* LAND USE	; ARABLE - LOWLAND PADDY - SINGLE
* LAND FORM	; MOUNTAINOUS - LOWLAND - VALLEY PLAIN
* TOPOGRAPHICAL DATA	; SLOPE 5 DEGREE; ASPECT N40W; ELEVATION 60 M; WATER TABLE 55 CM
* EROSION	; CLASS NONE TO SLIGHT; TYPE
* DRAINAGE	; RUNOFF MEDIUM; INTERNAL SLOW; SOIL DRANAGE INPERFECTLY DRAINED
* TAXONOMIC UNIT,	; GRL - 0 - 0 - ALL

1 $A1_p$ (15CM) 2.5Y 4/1 ; V.WET ; CLAY LOAM ; MEDIUM ORGANIC MATTER CONTENT
MASSIV STRUCTURE ,
MANY FINE DISTINCT MOTTLE (10YR 6/8)
FRIABLE (SL.HARD WHEN DRY) , MODERAT. STICKY , SLIGHTLY PLASTIC
COMPACTNESS - FINGER PENETRABLE , 10 MM CONE PENETRATION
MANY UBIQUITOUS ROOTS OF GRASS
DOMINANT STONE - FEW GRAVEL SLIGHTLY WEATHERED, SUBANGULAR SHAPED, DERIVED FROM GRANITE
ABRUPT SMOOTH BOUNDARY ;

2 $A1_2$ (15CM) 5Y 4/1 ; WET ; CLAY LOAM ; LOW ORGANIC MATTER CONTENT
MASSIV STRUCTURE ,
MANY FINE PROMINET MOTTLE (7.5YR 5/6)
FRIABLE , MODERAT. STICKY , SLIGHTLY PLASTIC
COMPACTNESS - NON-FINGER-PRINT , 23 MM CONE PENETRATION
FEW VERTICAL ROOTS OF GRASS
DOMINANT STONE - MANY GRAVEL SLIGHTLY WEATHERED, SUBANGULAR SHAPED, DERIVED FROM GRANITE
ABRUPT SMOOTH BOUNDARY ;

3 C1 (7CM) 10YR 5/8 ; WET ; HEAVY CLAY ; LOW ORGANIC MATTER CONTENT
MASSIV STRUCTURE ,
MANY FINE PROMINET MOTTLE (7.5YR 5/8)
FRIABLE (SL.HARD WHEN DRY) , VERY STICKY , VERY PLASTIC
COMPACTNESS - SHALLOW FINGER-PRINT , 13 MM CONE PENETRATION
DOMINANT STONE - FEW GRAVEL SLIGHTLY WEATHERED, SUBANGULAR SHAPED, DERIVED FROM GRANITE
FE IS MODERAT. ACCUMULATED
CLEAR SMOOTH BOUNDARY ;

```
4   C2 ( 14CM )   5Y 5/1 ; WET      ;   SANDY CLAY   ; LOW     ORGANIC MATTER CONTENT
                  MASSIV   STRUCTURE ,
                  FEW      FINE      DISTINCT MOTTLE (  7.5YR 5/8)
                  FRIABLE (HARD     WHEN DRY) ,    VERY   STICKY ,    VERY   PLASTIC
                  COMPACTNESS - SHALLOW FINGER-PRINT ,   18 MM CONE PENETRATION
                  DOMINANT STONE - MANY      GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED, DERIVED FROM GRANITE
                  FEMN IS SLIGHTLY ACCUMULATED
                  CLEAR     SMOOTH    BOUNDARY ;

5   C3 ( 10CM+)   5Y 5/1 ; X.WET    ;   SANDY CLAY   ; LOW     ORGANIC MATTER CONTENT
                  MASSIV   STRUCTURE ,
                  FEW      FINE      DISTINCT MOTTLE (  7.5YR 5/2)
                  FRIABLE                        ,    VERY   STICKY ,    VERY   PLASTIC
                  COMPACTNESS - SHALLOW FINGER-PRINT ,   15 MM CONE PENETRATION
                  DOMINANT STONE - ABUNDANT GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED, DERIVED FROM GRANITE
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************CHEMICAL DATA************

HOR		-----PH----- H2O	KCL	----------EXTR.BASES---------- K	NA	CA	MG	SUM	CEC	BASE -SAT.	----------TOTAL---------- C	N	C/N	P2O5	P2O5 -ABS.
				<-------------MEQ/100GSOIL-------------					>	<---------%---------		>		<--MG/100GSOIL-->	
1.	I	5.40	4.40	0.23	0.10	2.60	1.96	4.89	11.53	42.4	1.97	0.231	8.54	116.0	********
2.	I	********	********	********	********	********	********	********	********	********	********	********	********	********	********
3.	I	5.60	4.50	0.05	0.13	3.98	3.28	7.44	11.49	64.8	********	********	********	********	********
4.	I	6.20	4.90	0.06	0.14	4.59	4.83	9.62	12.84	74.9	********	********	********	********	********
5.	I	********	********	********	********	********	********	********	********	********	********	********	********	********	********

HOR		AV. P2O5	AV. SIO2	------FREE OXIDES------ MNO2	FE2O3	AL2O3
		<-MG/100GSOIL->		<----------%----------		>
1.	I	21.530	4.030	0.016	1.609	0.566
2.	I	********	********	********	********	********
3.	I	********	********	********	********	********
4.	I	********	********	********	********	********
5.	I	********	********	********	********	********

************PHYSICAL DATA************

HOR		BULK -DENS.	PART. -DENS.	H2O -CONT.	PORE	H2O -SAT.	-----MECHANICAL ANALYSIS----- C.SAND	F.SAND	SILT	CLAY	TEXT
				<-----------------------		%				----------------------->	
1.	I	1.05	2.52	46.5	58.3	84.0	********	********	********	********	****
2.	I	********	********	********	********	********	********	********	********	********	****
3.	I	1.27	2.65	39.5	52.0	96.7	********	********	********	********	****
4.	I	********	********	********	********	********	********	********	********	********	****
5.	I	********	********	********	********	********	********	********	********	********	****

11. Mapping unit 11

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* PREFECTURE,COUNTY          ;  KYOTO-FU,YOZA-GUN,KAYA-CHO

* PHYSIOGRAPHIC REGION       ;  KAYA-DANI

* SURVEY                     ;NAME(   KAYA'77      )    DATE(NOV.'77 )   OBSERVER(  KOTA  )

* PROFILE NO.                ; 136

* TYPE OF PROFILE            ;      PIT

* TYPE OF DESCRIPTION        ;    DETAILED

* PARENT MATERIAL            ;

* LAND USE                   ;      ARABLE     -       LOWLAND PADDY      -          SINGLE

* LAND FORM                  ;    MOUNTAINOUS  -    LOWLAND     -        FAN

* TOPOGRAPHICAL DATA         ;  SLOPE                ASPECT              ELEVATION           WATER TABLE
                                      2 DEGREE          N80W                  25 M                    CM

* EROSION                    ;  CLASS                                     TYPE
                                   NONE TO SLIGHT

* DRAINAGE                   ;  RUNOFF               INTERNAL            SOIL DRANAGE
                                    SLOW                MEDIUM                  MODERATELY      DRAINED

* TAXONOMIC UNIT,            ;     BLS  -   O    -   O   -   ALL

1      A1p( 15CM )    2.5Y 4/1 ; V.WET    ;     CLAY LOAM    ; MEDIUM   ORGANIC MATTER CONTENT
                   MASSIV   STRUCTURE ,
                   V.FRIAB.(SOFT    WHEN DRY) , SLIGHTLY STICKY , SLIGHTLY PLASTIC
                   COMPACTNESS - FINGER PENETRABLE    ,  11 MM CONE PENETRATION
                   MANY       UBIQUITOUS ROOTS OF      GRASS
                   DOMINANT STONE - MANY     GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED, DERIVED FROM GRANITE
                   ABRUPT     SMOOTH     BOUNDARY ;

2      A12(  8CM )      5Y 4/1 ; WET      ;  SANDY CLAY LOAM ; LOW      ORGANIC MATTER CONTENT
                   WEAKLY   DEVELOPED,MEDIUM    BLOCKY    STRUCTURE ,
                   MANY     FINE      DISTINCT MOTTLE (  7.5YR 5/6)
                   FRIABLE                    , SLIGHTLY STICKY , SLIGHTLY PLASTIC
                   COMPACTNESS - SHALLOW FINGER-PRINT ,  20 MM CONE PENETRATION
                   FEW        VERTICAL    ROOTS OF      GRASS
                   DOMINANT STONE - MANY     GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED, DERIVED FROM GRANITE
                   ABRUPT     SMOOTH     BOUNDARY ;

3      B2 ( 12CM )    2.5Y 4/4 ; WET      ;     CLAY LOAM    ; LOW      ORGANIC MATTER CONTENT
                   WEAKLY   DEVELOPED,MEDIUM    BLOCKY    STRUCTURE ,
                   ABUNDANT MEDIUM   DISTINCT MOTTLE (   10YR 5/8)
                   FRIABLE (HARD     WHEN DRY) , SLIGHTLY STICKY , SLIGHTLY PLASTIC
                   COMPACTNESS - SHALLOW FINGER-PRINT ,  20 MM CONE PENETRATION
                   DOMINANT STONE - MANY     GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED, DERIVED FROM GRANITE
                     FE IS MODERAT. ACCUMULATED
                   CLEAR      SMOOTH     BOUNDARY ;
```

4 GO (10CM+) 2.5Y 4/2 ; WET ; SANDY CLAY LOAM ; LOW ORGANIC MATTER CONTENT
WEAKLY DEVELOPED,MEDIUM BLOCKY STRUCTURE ,
MANY FINE DISTINCT MOTTLE (7.5YR 4/2)
FRIABLE , SLIGHTLY STICKY , SLIGHTLY PLASTIC
COMPACTNESS - SHALLOW FINGER-PRINT , 20 MM CONE PENETRATION
DOMINANT STONE - MANY GRAVEL SLIGHTLY WEATHERED, SUBANGULAR SHAPED, DERIVED FROM GRANITE
FEMN IS SLIGHTLY ACCUMULATED

************CHEMICAL DATA************

HOR		-----PH----- H2O	KCL	------------EXTR.BASES----------- K	NA	CA	MG	SUM	CEC	BASE -SAT.	------------TOTAL------------ C	N	C/N	P205	P205 -ABS.
				<-------------		MEQ/100GSOIL		------------->		<---------	%	--------->	<--MG/100GSOIL-->	
1.	I	5.30	4.50	0.35	0.09	3.59	0.89	4.92	9.92	49.6	2.00	0.164	12.21	112.0	********
2.	I	******	******	******	******	******	******	******	******	******	******	******	******	******	******
3.	I	5.50	4.50	0.15	0.09	4.05	0.76	5.05	8.58	58.9	******	******	******	******	******
4.	I	******	******	******	******	******	******	******	******	******	******	******	******	******	******

HOR		AV. P205	AV. SIO2	------FREE OXIDES------ MNO2	FE2O3	AL2O3
		<-MG/100GSOIL->		<----------	%	---------->
1.	I	24.710	3.880	0.016	1.766	1.228
2.	I	********	********	********	********	********
3.	I	********	********	********	********	********
4.	I	********	********	********	********	********

************PHYSICAL DATA************

HOR		BULK -DENS.	PART. -DENS.	H2O -CONT.	PORE	H2O -SAT.	-----MECHANICAL ANALYSIS----- C.SAND	F.SAND	SILT	CLAY	TEXT
				<-------------			%			------------->	
1.	I	0.88	2.45	62.0	63.9	85.9	********	********	********	********	****
2.	I	********	********	********	********	********	********	********	********	********	****
3.	I	1.51	2.60	26.1	42.1	93.6	********	********	********	********	****
4.	I	********	********	********	********	********	********	********	********	********	****

12. Mapping unit 12

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* PREFECTURE,COUNTY          ;  KYOTO-FU,YOZA-GUN,KAYA-CHO
* PHYSIOGRAPHIC REGION       ;  KAYA-DANI
* SURVEY                     ;NAME(  KAYA'77    )   DATE(NOV.'77 )   OBSERVER(  KOTA  )
* PROFILE NO.                ; 204
* TYPE OF PROFILE            ;      PIT
* TYPE OF DESCRIPTION        ;    DETAILED
* PARENT MATERIAL            ;
* LAND USE                   ;      ARABLE    -     LOWLAND PADDY     -        SINGLE
* LAND FORM                  ;    MOUNTAINOUS  -  TERRACE-FAN  -  HIGH TERRACE
* TOPOGRAPHICAL DATA         ;  SLOPE              ASPECT             ELEVATION         WATER TABLE
                                    2 DEGREE          N75W                 42 M              50 CM
* EROSION                    ;  CLASS                                  TYPE
                                   NONE TO SLIGHT
* DRAINAGE                   ;  RUNOFF             INTERNAL           SOIL DRANAGE
                                    SLOW               SLOW                 INPERFECTLY     DRAINED
* TAXONOMIC UNIT,            ;  .  PSG  -   O   -   O   -   ALL

1     A1p( 15CM )     10YR 5/3 ; V.WET    ;    LIGHT CLAY    ; MEDIUM   ORGANIC MATTER CONTENT
                 MASSIV   STRUCTURE ,                         ( BREAKES TO WEAKLY   DEVELOPED FINE      NUTY   STRUCTURE )
                 MANY     MEDIUM   FAINT    MOTTLE (   10YR 5/6)
                 FRIABLE (SL.HARD WHEN DRY) , MODERAT. STICKY ,   VERY   PLASTIC
                 COMPACTNESS - DEEP FINGER-PRINT    ,  15 MM CONE PENETRATION  .
                 MANY      UBIQUITOUS ROOTS OF      GRASS
                 DOMINANT STONE - FEW      GRAVEL   SLIGHTLY WEATHERED, ANGULAR      SHAPED, DERIVED FROM GRANITE
                 ABRUPT     SMOOTH     BOUNDARY ;

2     A12(  8CM )     2.5Y 5/1 ; WET      ;    LIGHT CLAY    ; LOW      ORGANIC MATTER CONTENT
                 MASSIV   STRUCTURE ,                         ( BREAKES TO WEAKLY   DEVELOPED MEDIUM   BLOCKY   STRUCTURE )
                 ABUNDANT MEDIUM   PROMINET MOTTLE (   10YR 5/6)
                 FRIABLE                   ,   VERY   STICKY ,   VERY   PLASTIC
                 COMPACTNESS - SHALLOW FINGER-PRINT ,  22 MM CONE PENETRATION
                 FEW       VERTICAL     ROOTS OF      GRASS
                 DOMINANT STONE - MANY     GRAVEL   SLIGHTLY WEATHERED, ANGULAR      SHAPED, DERIVED FROM GRANITE
                 CLEAR      SMOOTH     BOUNDARY ;

3     C1 ( 10CM )     2.5Y 5/2 ; WET      ;    HEAVY CLAY    ; LOW      ORGANIC MATTER CONTENT
                 MASSIV   STRUCTURE ,                         ( BREAKES TO WEAKLY   DEVELOPED MEDIUM   BLOCKY   STRUCTURE )
                 ABUNDANT MEDIUM   PROMINET MOTTLE (   10YR 5/6) ; FEW     FINE     DISTINCT CUTAN (   2.5Y 5/2)
                 FRIABLE (HARD    WHEN DRY) ,   VERY   STICKY ,   VERY   PLASTIC
                 COMPACTNESS - SHALLOW FINGER-PRINT ,  15 MM CONE PENETRATION
                 DOMINANT STONE - FEW      GRAVEL   SLIGHTLY WEATHERED, ANGULAR      SHAPED, DERIVED FROM GRANITE
                 CLEAR      SMOOTH     BOUNDARY ;
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4 C_2 (15CM+) 2.5Y 5/1 ; V.WET ; LIGHT CLAY ; LOW ORGANIC MATTER CONTENT
MASSIV STRUCTURE ,
ABUNDANT MEDIUM PROMINET MOTTLE (7.5YR 5/8)
, VERY STICKY , VERY PLASTIC
COMPACTNESS - SHALLOW FINGER-PRINT , 18 MM CONE PENETRATION

************CHEMICAL DATA************

HOR		-----PH-----		-----------EXTR.BASES-----------						BASE	-----------TOTAL-----------				P2O5
		H2O	KCL	K	NA	CA	MG	SUM	CEC	-SAT.	C	N	C/N	P2O5	-ABS.
				<-------------MEQ/100GSOIL------------->						<---------%--------->				<--MG/100GSOIL-->	
1.	I	4.70	4.20	0.18	0.07	1.46	2.29	4.00	11.78	34.0	1.66	0.171	9.72	64.0	********
2.	I**														
3.	I	5.70	4.60	0.10	0.09	2.28	4.17	6.64	10.42	63.7	**				
4.	I**														

HOR		AV. P2O5	AV. SIO2	------FREE OXIDES------ MNO2	FE2O3	AL2O3
		<-MG/100GSOIL->		<----------%---------->		
1.	I	2.050	8.430	0.010	3.075	0.968
2.	I****************			***********************		
3.	I****************			***********************		
4.	I****************			***********************		

************PHYSICAL DATA************

HOR		BULK -DENS.	PART. -DENS.	H2O -CONT.	PORE	H2O -SAT.	-----MECHANICAL ANALYSIS----- C.SAND	F.SAND	SILT	CLAY	TEXT
				<------------------------		%	------------------------>				
1.	I	1.06	2.54	38.8	58.4	70.0	*********************************				****
2.	I**										****
3.	I	1.41	2.59	29.1	45.6	90.1	*********************************				****
4.	I**										****

13. Mapping unit 13

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* PREFECTURE,COUNTY            ;   KYOTO-FU,YOZA-GUN,KAYA-CHO

* PHYSIOGRAPHIC REGION         ;   KAYA-DANI

* SURVEY                       ;NAME(   KAYA'77       )    DATE(NOV.'77 )   OBSERVER(  KOTA  )

* PROFILE NO.                  ;  116

* TYPE OF PROFILE              ;        PIT

* TYPE OF DESCRIPTION          ;     DETAILED

* PARENT MATERIAL              ;          GRANITE

* LAND USE                     ;     BUSH FALLOW   -                         -

* LAND FORM                    ;     MOUNTAINOUS   -  TERRACE-FAN   -        FAN

* TOPOGRAPHICAL DATA           ;   SLOPE              ASPECT              ELEVATION           WATER TABLE
                                         5 DEGREE          E10S                  30 M                  CM

* EROSION                      ;   CLASS                                     TYPE
                                      NONE TO SLIGHT

* DRAINAGE                     ;   RUNOFF             INTERNAL            SOIL DRANAGE
                                       SLOW               MEDIUM                 MODERATELY      DRAINED

* TAXONOMIC UNIT,              ;      BLS  -   0    -   0    -   ALL

1      A1p ( 23CM )     10YR 3/1 ; WET       ;     CLAY LOAM    ; MEDIUM   ORGANIC MATTER CONTENT
                       SNG.GRA. STRUCTURE ,
                       FRIABLE (SL.HARD WHEN DRY) , SLIGHTLY STICKY , SLIGHTLY PLASTIC
                       COMPACTNESS - DEEP FINGER-PRINT    ,   10 MM CONE PENETRATION
                       MANY       UBIQUITOUS ROOTS OF       GRASS
                       DOMINANT STONE - MANY     GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED, DERIVED FROM GRANITE
                       ABRUPT    SMOOTH    BOUNDARY ;

2      B2 (  8CM )      2.5Y 3/3 ; WET       ;     CLAY LOAM    ; LOW      ORGANIC MATTER CONTENT
                       MASSIV   STRUCTURE ,
                       MANY     FINE      DISTINCT MOTTLE (   10YR 5/8)
                       FRIABLE (        WHEN DRY) , SLIGHTLY STICKY , SLIGHTLY PLASTIC
                       COMPACTNESS - SHALLOW FINGER-PRINT ,   17 MM CONE PENETRATION
                       DOMINANT STONE - MANY     GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED, DERIVED FROM GRANITE
                         FE IS SLIGHTLY ACCUMULATED
                       ABRUPT    SMOOTH    BOUNDARY ;

3      C  ( 20CM+)      10YR 2/1 ; WET       ;     CLAY LOAM    ; MEDIUM   ORGANIC MATTER CONTENT
                       MASSIV   STRUCTURE ,
                       FRIABLE                  , SLIGHTLY STICKY , SLIGHTLY PLASTIC
                       COMPACTNESS - SHALLOW FINGER-PRINT ,
                       DOMINANT STONE - MANY     GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED, DERIVED FROM GRANITE
```

************CHEMICAL DATA************

HOR		-----PH-----		-----------EXTR.BASES-----------						BASE	-----------TOTAL-----------				P2O5
		H2O	KCL	K	NA	CA	MG	SUM	CEC	-SAT.	C	N	C/N	P2O5	-ABS.
				<-------------MEQ/100GSOIL-------------					->	<---------%---------		->		<--MG/100GSOIL-->	
1.	I	7.20	6.20	1.48	0.05	12.01	1.20	14.74	14.85	99.3	2.02	0.137	14.74	192.0	********
2.	I	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********
3.	I	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********

HOR		AV. P2O5	AV. SIO2	------FREE OXIDES------ MNO2	FE2O3	AL2O3
		<-MG/100GSOIL->		<----------%----------		->
1.	I	103.530	132.430	0.088	2.409	1.607
2.	I	********	********	********	********	********
3.	I	********	********	********	********	********

************PHYSICAL DATA************

HOR		BULK -DENS.	PART. -DENS.	H2O -CONT.	PORE	H2O -SAT.	-----MECHANICAL ANALYSIS----- C.SAND	F.SAND	SILT	CLAY	TEXT
				<------------------------			%			------------------------>	
1.	I	1.20	2.52	37.8	52.1	87.5	********	********	********	********	****
2.	I	********	********	********	********	********	********	********	********	********	****
3.	I	********	********	********	********	********	********	********	********	********	****

14. Mapping unit 14

* PREFECTURE,COUNTY	;	KYOTO-FU,YOZA-GUN,KAYA-CHO
* PHYSIOGRAPHIC REGION	;	KAYA-DANI
* SURVEY	;	NAME(KAYA'77) DATE(NOV.'77) OBSERVER(KOTA)
* PROFILE NO.	;	123
* TYPE OF PROFILE	;	PIT
* TYPE OF DESCRIPTION	;	DETAILED
* PARENT MATERIAL	;	
* LAND USE	;	ARABLE - LOWLAND PADDY - SINGLE
* LAND FORM	;	MOUNTAINOUS - TERRACE-FAN - HIGH TERRACE
* TOPOGRAPHICAL DATA	;	SLOPE 6 DEGREE; ASPECT N10W; ELEVATION 80 M; WATER TABLE CM
* EROSION	;	CLASS NONE TO SLIGHT; TYPE
* DRAINAGE	;	RUNOFF MEDIUM; INTERNAL V.SLOW; SOIL DRANAGE INPERFECTLY DRAINED
* TAXONOMIC UNIT,	;	PSG - 0 - 0 - ALL

1 $A1_p$ (12CM) 10YR 4/2 ; V.WET ; SILTY CLAY LOAM ; MEDIUM ORGANIC MATTER CONTENT
WEAKLY DEVELOPED,MEDIUM BLOCKY STRUCTURE ,
MANY MEDIUM DISTINCT MOTTLE (10YR 5/8)
FRIABLE (HARD WHEN DRY) , SLIGHTLY STICKY , VERY PLASTIC
COMPACTNESS - DEEP FINGER-PRINT , 13 MM CONE PENETRATION
MANY UBIQUITOUS ROOTS OF GRASS
ABRUPT SMOOTH BOUNDARY ;

2 $A1_2$ (4CM) 2.5Y 5/1 ; V.WET ; SILTY CLAY LOAM ; MEDIUM ORGANIC MATTER CONTENT
WEAKLY DEVELOPED,MEDIUM BLOCKY STRUCTURE ,
MANY FINE DISTINCT MOTTLE (10YR 5/8)
FRIABLE , SLIGHTLY STICKY , VERY PLASTIC
COMPACTNESS - SHALLOW FINGER-PRINT , 20 MM CONE PENETRATION
MANY VERTICAL ROOTS OF GRASS
ABRUPT SMOOTH BOUNDARY ;

3 $B2_1$ (6CM) 10YR 5/6 ; WET ; HEAVY CLAY ; LOW ORGANIC MATTER CONTENT
WEAKLY DEVELOPED,MEDIUM BLOCKY STRUCTURE ,
PROFUSE FINE DISTINCT MOTTLE (10YR 5/8)
FRIABLE , VERY STICKY , VERY PLASTIC
COMPACTNESS - SHALLOW FINGER-PRINT , 17 MM CONE PENETRATION
FEW VERTICAL ROOTS OF GRASS
FE IS MODERAT. ACCUMULATED
ABRUPT SMOOTH BOUNDARY ;

4 B2$_2$(18CM) 7.5YR 5/2 ; WET ; HEAVY CLAY ; LOW ORGANIC MATTER CONTENT
WEAKLY DEVELOPED,MEDIUM BLOCKY STRUCTURE ,
FEW FINE FAINT MOTTLE (10YR 5/8)
FRIABLE (HARD WHEN DRY) , VERY STICKY , VERY PLASTIC
COMPACTNESS - SHALLOW FINGER-PRINT , 22 MM CONE PENETRATION
MN IS SLIGHTLY ACCUMULATED
ABRUPT SMOOTH BOUNDARY ;

5 C (10CM+) 10YR 5/6 ; WET ; HEAVY CLAY ; LOW ORGANIC MATTER CONTENT
FRIABLE (HARD WHEN DRY) , VERY STICKY , VERY PLASTIC
COMPACTNESS - SHALLOW FINGER-PRINT , 18 MM CONE PENETRATION

************CHEMICAL DATA************

HOR		-----PH----- H2O	KCL	------EXTR.BASES------ K	NA	CA	MG	SUM	CEC	BASE -SAT.	------TOTAL------ C	N	C/N	P2O5	P2O5 -ABS.
				<-------------MEQ/100GSOIL					------------->	<---------	%---------	>		<--MG/100GSOIL-->	
1.	I	5.00	4.30	0.24	0.15	3.61	1.88	5.88	13.25	44.4	2.16	0.198	10.89	113.0	********
2.	I**														
3.	I**														
4.	I	6.10	5.50	0.31	0.30	6.59	5.52	12.72	15.68	81.1	************************************				
5.	I	5.90	5.10	0.15	0.12	7.24	4.46	11.97	15.46	77.4	************************************				

HOR		AV. P2O5	AV. SIO2	------FREE OXIDES------ MNO2	FE2O3	AL2O3
		<-MG/100GSOIL->		<-----------	%----------	>
1.	I	11.820	10.140	0.007	3.709	1.218
2.	I***************			***********************		
3.	I***************			***********************		
4.	I***************			***********************		
5.	I***************			***********************		

************PHYSICAL DATA************

HOR		BULK -DENS.	PART. -DENS.	H2O -CONT.	PORE	H2O -SAT.	-----MECHANICAL ANALYSIS----- C.SAND	F.SAND	SILT	CLAY	TEXT
				<------------------------			%------------------------>				
1.	I	1.12	2.53	44.8	55.5	90.6	********************************				****
2.	I**										****
3.	I**										****
4.	I	1.42	2.55	30.4	44.4	97.1	********************************				****
5.	I**										****

15. Mapping unit 15

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* PREFECTURE,COUNTY           ;  KYOTO-FU,YOZA-GUN,KAYA-CHO
* PHYSIOGRAPHIC REGION        ;  KAYA-DANI
* SURVEY                      ;NAME(  KAYA'77      )   DATE(NOV.'77 )  OBSERVER(  KOTA  )
* PROFILE NO.                 ; 133
* TYPE OF PROFILE             ;       PIT
* TYPE OF DESCRIPTION         ;   DETAILED
* PARENT MATERIAL             ;
* LAND USE                    ;       ARABLE    -      LOWLAND PADDY      -          SINGLE
* LAND FORM                   ;   MOUNTAINOUS   -   LOWLAND     -   VALLEY PLAIN
* TOPOGRAPHICAL DATA          ;  SLOPE               ASPECT              ELEVATION         WATER TABLE
                                       5 DEGREE         N30W                   33 M                CM
* EROSION                     ;  CLASS                                   TYPE
                                    NONE TO SLIGHT
* DRAINAGE                    ;  RUNOFF              INTERNAL            SOIL DRANAGE
                                    MEDIUM                SLOW                   MODERATELY       DRAINED
* TAXONOMIC UNIT,             ;     BLS  -   0    -   0   -   ALL

1      A1p( 12CM )     10YR 4/2 ; V.WET    ;     CLAY LOAM    ; MEDIUM   ORGANIC MATTER CONTENT
                    MASSIV   STRUCTURE ,
                    MANY     MEDIUM   FAINT    MOTTLE (    10YR 5/8)
                    FRIABLE (HARD    WHEN DRY) , SLIGHTLY STICKY , MODERAT. PLASTIC
                    COMPACTNESS - FINGER PENETRABLE     ,  12 MM CONE PENETRATION
                    MANY      UBIQUITOUS ROOTS OF      GRASS
                    DOMINANT STONE - FEW      GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED,
                    CLEAR     SMOOTH    BOUNDARY ;

2      A1l(  9CM )       5Y 4/1 ; WET      ;    LIGHT CLAY    ; LOW      ORGANIC MATTER CONTENT
                    MASSIV   STRUCTURE ,
                    MANY     MEDIUM   DISTINCT MOTTLE (    10YR 5/8)
                    FRIABLE                  , MODERAT. STICKY , MODERAT. PLASTIC
                    COMPACTNESS - DEEP FINGER-PRINT     ,  15 MM CONE PENETRATION
                    FEW       VERTICAL    ROOTS OF      GRASS
                    DOMINANT STONE - MANY     GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED,
                      FE IS SLIGHTLY ACCUMULATED
                    CLEAR     SMOOTH    BOUNDARY ;
```

3 GO (20CM+) 10YR 4/2 ; WET ; HEAVY CLAY ; LOW ORGANIC MATTER CONTENT
MASSIV STRUCTURE ,
MANY MEDIUM FAINT MOTTLE (*/*)
FRIABLE (HARD WHEN DRY) , VERY STICKY , VERY PLASTIC
COMPACTNESS - SHALLOW FINGER-PRINT , 20 MM CONE PENETRATION
DOMINANT STONE - PROFUSE COBBLE SLIGHTLY WEATHERED, SUBANGULAR SHAPED,

************CHEMICAL DATA************

HOR		-----PH----- H2O	KCL	-----------EXTR.BASES----------- K	NA	CA	MG	SUM	CEC	BASE -SAT.	------------TOTAL------------ C	N	C/N	P2O5	P2O5 -ABS.
				<-------------MEQ/100GSOIL-------------					------------>	<----------	%--------->			<--MG/100GSOIL	-->
1.	I	4.80	4.20	0.18	0.10	1.99	5.81	8.08	13.70	59.0	2.27	0.143	15.88	72.0	********
2.	I	********	********	********	********	********	********	********	********	********	********	********	********	********	********
3.	I	5.90	5.80	0.10	0.10	4.16	9.54	13.90	15.74	88.3	********	********	********	********	********

HOR		AV. P2O5	AV. SIO2	------FREE OXIDES------ MNO2	FE2O3	AL2O3
		<-MG/100GSOIL->		<-----------	%----------	>
1.	I	2.820	15.000	0.01[illegible]	6.511	1.451
2.	I	********	********	********	********	********
3.	I	********	********	********	********	********

************PHYSICAL DATA************

HOR		BULK -DENS.	PART. -DENS.	H2O -CONT.	PORE	H2O -SAT.	-----MECHANICAL ANALYSIS----- C.SAND	F.SAND	SILT	CLAY	TEXT
				<-------------------------			%------------------------			>	
1.	I	1.02	2.61	50.4	61.1	83.8	********	********	********	********	****
2.	I	1.23	2.64	42.3	53.3	97.7	********	********	********	********	****
3.	I	********	********	********	********	********	********	********	********	********	****

16. Mapping unit 16

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* PREFECTURE,COUNTY          ;  KYOTO-FU,YOZA-GUN,KAYA-CHO
* PHYSIOGRAPHIC REGION       ;  KAYA-DANI
* SURVEY                     ;NAME(  KAYA'77     )   DATE(NOV.'77 )  OBSERVER(  KOTA  )
* PROFILE NO.                ; 189
* TYPE OF PROFILE            ;     PIT
* TYPE OF DESCRIPTION        ;   DETAILED
* PARENT MATERIAL            ;
* LAND USE                   ;     ARABLE     -     LOWLAND PADDY     -        SINGLE
* LAND FORM                  ;   MOUNTAINOUS  -   LOWLAND     -       FAN
* TOPOGRAPHICAL DATA         ;  SLOPE             ASPECT           ELEVATION        WATER TABLE
                                    8 DEGREE          N50W             120 M             CM
* EROSION                    ;  CLASS                              TYPE
                                  NONE TO SLIGHT
* DRAINAGE                   ;  RUNOFF            INTERNAL         SOIL DRANAGE
                                  MEDIUM            MEDIUM                 WELL       DRAINED
* TAXONOMIC UNIT,            ;    BLS  -   0   -   0 -  -   ALL

1    A1p( 13CM )   2.5Y 4/1 ; WET     ;    CLAY LOAM    ; MEDIUM   ORGANIC MATTER CONTENT
               MASSIV   STRUCTURE ,                  ( BREAKES TO WEAKLY   DEVELOPED FINE    CRUMB    STRUCTURE )
               FRIABLE (SOFT    WHEN DRY) , MODERAT. STICKY , MODERAT. PLASTIC
               COMPACTNESS - SHALLOW FINGER-PRINT ,   20 MM CONE PENETRATION
               MANY     UBIQUITOUS ROOTS OF     GRASS
               DOMINANT STONE - MANY     GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED,
               ABRUPT     SMOOTH    BOUNDARY ;

2    A12(  5CM )   2.5Y 4/2 ; WET     ;    CLAY LOAM    ; MEDIUM   ORGANIC MATTER CONTENT
               MASSIV   STRUCTURE ,                  ( BREAKES TO WEAKLY   DEVELOPED FINE    BLOCKY   STRUCTURE )
               FEW      FINE      FAINT     MOTTLE (   10YR 5/6)
               FRIABLE                  , MODERAT. STICKY , MODERAT. PLASTIC
               COMPACTNESS - SHALLOW FINGER-PRINT ,   23 MM CONE PENETRATION
               FEW       VERTICAL    ROOTS OF      GRASS
               DOMINANT STONE - MANY     GRAVEL   SLIGHTLY WEATHERED, SUBANGULAR   SHAPED,
               ABRUPT     SMOOTH    BOUNDARY ;

3    B21(  6CM )   10YR 4/3 ; WET     ;   LIGHT CLAY    ; LOW      ORGANIC MATTER CONTENT
               MASSIV   STRUCTURE ,                  ( BREAKES TO WEAKLY   DEVELOPED FINE    BLOCKY   STRUCTURE )
               ABUNDANT FINE     DISTINCT MOTTLE (   10YR 5/8) ; FEW     FINE     DISTINCT CUTAN (   10YR 4/3)
               FRIABLE (HARD    WHEN DRY) ,   VERY    STICKY ,   VERY   PLASTIC
               COMPACTNESS - SHALLOW FINGER-PRINT ,   24 MM CONE PENETRATION
               DOMINANT STONE - MANY     S.PEBBLE SLIGHTLY WEATHERED, SUBANGULAR   SHAPED,
                 FE IS SLIGHTLY ACCUMULATED
               CLEAR      SMOOTH    BOUNDARY ;
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4      B2₂ ( 12CM )      10YR 5/3 ; WET        ;    LIGHT CLAY     ; LOW       ORGANIC MATTER CONTENT
                     MASSIV   STRUCTURE ,                                      ( BREAKES TO WEAKLY   DEVELOPED FINE      BLOCKY    STRUCTURE )
                     MANY     FINE      DISTINCT MOTTLE (    10YR 5/8) ; FEW       FINE      DISTINCT CUTAN (    10YR 5/3)
                     FRIABLE                       ,   VERY    STICKY ,    VERY    PLASTIC
                     COMPACTNESS - SHALLOW FINGER-PRINT ,    24 MM CONE PENETRATION
                     DOMINANT STONE - MANY      PEBBLE   SLIGHTLY WEATHERED, SUBANGULAR    SHAPED,
                     CLEAR      WAVY       BOUNDARY ;

5      C  ( 10CM+)       10YR 4/4 ; WET        ;    LIGHT CLAY     ; LOW       ORGANIC MATTER CONTENT
                     WEAKLY   DEVELOPED,FINE       CRUMB      STRUCTURE ,
                     FRIABLE (SL.HARD WHEN DRY) ,   VERY    STICKY ,    VERY    PLASTIC
                     COMPACTNESS - SHALLOW FINGER-PRINT ,    20 MM CONE PENETRATION
                     DOMINANT STONE - MANY      PEBBLE   SLIGHTLY WEATHERED, SUBANGULAR    SHAPED,
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************CHEMICAL DATA************

HOR	PH H2O	PH KCL	EXTR.BASES K	EXTR.BASES NA	EXTR.BASES CA	EXTR.BASES MG	EXTR.BASES SUM	CEC	BASE -SAT.	TOTAL C	TOTAL N	TOTAL C/N	TOTAL P2O5	P2O5 -ABS.
			<------	MEQ/100GSOIL				------>	<----	%	---->		<-- MG/100GSOIL	-->
1.	I 6.10	5.30	0.41	0.12	8.07	2.29	10.89	15.54	70.1	2.58	0.316	8.16	286.0	********
2.	I******	******	******	******	******	******	******	******	******	******	******	******	******	******
3.	I 6.60	5.70	0.51	0.08	5.68	1.45	7.72	10.90	70.8	******	******	******	******	******
4.	I******	******	******	******	******	******	******	******	******	******	******	******	******	******
5.	I 6.50	5.60	0.79	0.10	6.03	1.59	8.51	12.43	68.5	******	******	******	******	******

HOR	AV. P2O5	AV. SIO2	FREE OXIDES MNO2	FREE OXIDES FE2O3	FREE OXIDES AL2O3
	<-MG/100GSOIL	->	<------	%	------>
1.	I 249.630	24.300	0.033	2.922	1.204
2.	I********	********	********	********	********
3.	I********	********	********	********	********
4.	I********	********	********	********	********
5.	I********	********	********	********	********

************PHYSICAL DATA************

HOR	BULK -DENS.	PART. -DENS.	H2O -CONT.	PORE	H2O -SAT.	MECHANICAL ANALYSIS C.SAND	MECHANICAL ANALYSIS F.SAND	MECHANICAL ANALYSIS SILT	MECHANICAL ANALYSIS CLAY	TEXT
			<------			%			------>	
1.	I 1.15	2.46	40.2	53.1	87.2	******	******	******	******	****
2.	I******	******	******	******	******	******	******	******	******	****
3.	I******	******	******	******	******	******	******	******	******	****
4.	I******	******	******	******	******	******	******	******	******	****
5.	I******	******	******	******	******	******	******	******	******	****

17. Mapping unit 17

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* PREFECTURE,COUNTY         ;  KYOTO-FU,YOZA-GUN,KAYA-CHO
* PHYSIOGRAPHIC REGION      ;  KAYA-DANI
* SURVEY                    ;NAME(  KAYA'77     )  DATE(NOV.'77 )  OBSERVER(  KOTA  )
* PROFILE NO.               ;  215
* TYPE OF PROFILE           ;     PIT
* TYPE OF DESCRIPTION       ;   DETAILED
* PARENT MATERIAL           ;       GRANITE
* LAND USE                  ;     ARABLE    -    LOWLAND PADDY    -        SINGLE
* LAND FORM                 ;   MOUNTAINOUS  -  LOWLAND   -   VALLEY PLAIN
* TOPOGRAPHICAL DATA        ;  SLOPE            ASPECT          ELEVATION        WATER TABLE
                                  3 DEGREE         N80W             35 M             CM
* EROSION                   ;  CLASS                            TYPE
                                 NONE TO SLIGHT
* DRAINAGE                  ;  RUNOFF           INTERNAL        SOIL DRANAGE
                                  SLOW             SLOW                POORLY       DRAINED
* TAXONOMIC UNIT,           ;    GRL  -  O  -  O  -  UG

1    A1p( 14CM )  2.5Y 5/1 ; V.WET   ;   CLAY LOAM   ; MEDIUM  ORGANIC MATTER CONTENT
                 MASSIV   STRUCTURE ,
                 MANY     FINE     FAINT    MOTTLE (   10YR 5/8)
                 FRIABLE (SOFT    WHEN DRY) , SLIGHTLY STICKY , SLIGHTLY PLASTIC
                 COMPACTNESS - DEEP FINGER-PRINT    ,  13 MM CONE PENETRATION
                 MANY     UBIQUITOUS ROOTS OF     GRASS
                 DOMINANT STONE - FEW     GRAVEL  SLIGHTLY WEATHERED, SUBANGULAR  SHAPED, DERIVED FROM GRANITE
                 ABRUPT     SMOOTH    BOUNDARY ;

2    C1 (  8CM )  2.5Y 5/3 ; WET      ; SANDY CLAY LOAM ; LOW     ORGANIC MATTER CONTENT
                 MASSIV   STRUCTURE ,
                 FEW      FINE     DISTINCT MOTTLE (   10YR 5/8)
                 FRIABLE                  , MODERAT. STICKY , SLIGHTLY PLASTIC
                 COMPACTNESS - SHALLOW FINGER-PRINT ,  20 MM CONE PENETRATION
                 FEW      VERTICAL    ROOTS OF     GRASS
                 DOMINANT STONE - MANY    GRAVEL  SLIGHTLY WEATHERED, SUBANGULAR  SHAPED, DERIVED FROM GRANITE
                 SUBORDINATE STONE - FEW     PEBBLE   SLIGHTLY WEATHERED,
                 ABRUPT     SMOOTH    BOUNDARY ;

3    C2 ( 12CM )  2.5Y 7/4 ; WET      ; SANDY CLAY LOAM ; LOW     ORGANIC MATTER CONTENT
                 MASSIV   STRUCTURE ,
                 FEW      FINE     DISTINCT MOTTLE (  7.5YR 5/6)
                 FRIABLE                  , MODERAT. STICKY , MODERAT. PLASTIC
                 COMPACTNESS - SHALLOW FINGER-PRINT ,  16 MM CONE PENETRATION
                 DOMINANT STONE - MANY    GRAVEL  SLIGHTLY WEATHERED, SUBANGULAR  SHAPED, DERIVED FROM GRANITE
                 ABRUPT     IRREGUL.  BOUNDARY ;
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4 C_3 (14CM+) 5GY 5/1 ; WET ; SANDY CLAY LOAM ; LOW ORGANIC MATTER CONTENT
MASSIV STRUCTURE ,
FRIABLE , SLIGHTLY STICKY , SLIGHTLY PLASTIC
COMPACTNESS - SHALLOW FINGER-PRINT , 18 MM CONE PENETRATION
DOMINANT STONE - FEW GRAVEL SLIGHTLY WEATHERED, SUBANGULAR SHAPED, DERIVED FROM GRANITE
FERROUS ION COLOR IS MODERAT. APPEARED ;

************CHEMICAL DATA************

HOR		-----PH----- H2O	KCL	------------EXTR.BASES----------- K	NA	CA	MG	SUM	CEC	BASE -SAT.	-----------TOTAL----------- C	N	C/N	P2O5	P2O5 -ABS.
				<-------------MEQ/100GSOIL------------->						<---------%--------->			<--MG/100GSOIL-->	
1.	I	5.20	4.20	0.21	0.09	3.33	1.03	4.66	10.23	45.6	1.42	0.128	11.07	60.0	****
2.	I	5.30	4.30	0.11	0.12	3.61	1.28	5.12	9.64	53.1	****	****	****	****	****
3.	I	****	****	****	****	****	****	****	****	****	****	****	****	****	****
4.	I	****	****	****	****	****	****	****	****	****	****	****	****	****	****

HOR		AV. P2O5	AV. SIO2	------FREE OXIDES------ MNO2	FE2O3	AL2O3
		<-MG/100GSOIL->		<----------%---------->		
1.	I	14.270	4.110	0.023	2.572	0.802
2.	I	****	****	****	****	****
3.	I	****	****	****	****	****
4.	I	****	****	****	****	****

************PHYSICAL DATA************

HOR		BULK -DENS.	PART. -DENS.	H2O -CONT.	PORE	H2O -SAT.	-----MECHANICAL ANALYSIS----- C.SAND	F.SAND	SILT	CLAY	TEXT
				<------------------------		-%	------------------------>				
1.	I	1.07	2.59	47.8	58.8	86.7	****	****	****	****	****
2.	I	1.52	2.67	24.5	42.9	86.9	****	****	****	****	****
3.	I	****	****	****	****	****	****	****	****	****	****
4.	I	****	****	****	****	****	****	****	****	****	****